

**School of Information Systems**

**RFID in Perishable Foods Transportation:  
An Analysis of the Adoption of Time-Temperature Monitoring  
Technology for the Transport of Perishable Foods**

**Volume One**

**Submitted in fulfilment of the requirements for the degree of  
Doctor of Philosophy**

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## **Abstract**

This research provides an analysis of the adoption of time-temperature monitoring technologies (particularly RFID) for the transport of perishable foods. These technologies have been used to provide information during the transport of other commodities but there are very few studies on their adoption and use in the perishable food industry. Increasingly the perishable food industry is under pressure to provide higher quality, higher nutritional fresh foods and to address stricter standards covering food safety. There has also been real market pressure for organisations to minimise supply chain management costs, and maximise customer service and market opportunities. Therefore, the objective of this research was to examine the potential application of time-temperature monitoring in cold (refrigerated) supply chain management in Australia.

This thesis presents five industry case studies that seek to understand the nature of the adoption of technology for environmental monitoring of the transport of perishable foods. These case studies explore the use of time-temperature monitoring equipment for the quality assurance of perishable food, supply chain relationship maintenance, fault diagnosis, and reduction of costs associated with reverse logistics.

This research adopts a post-positivist epistemology and employs qualitative analysis of multiple case studies, using semi-structured interviews and a critical analysis approach to the derivation of effect-outcome models associated with the adoption of this technology. These approaches provide considerable insight into the logistics management of the transport of perishable foods across a range of industries, including seafood export, confectionary distribution and research into food safety.

This exploratory research has identified a number of dependent variables, including Return on Investment, that characterise the outcomes of decisions relating to the adoption of time-temperature monitoring technologies. The study provides a preliminary model as the basis for further investigation into the use of time-temperature monitoring technology for surveillance of perishable foods. These findings are also relevant to industry in providing insight into the key issues that need

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to be considered when integrating environmental monitoring into supply chain management practices.



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## **Glossary**

### **Adoption of Technology**

A decision to make full use of an innovation as the best course of action available and rejection as a decision not adopt an innovation (Rogers, 1983:21)

### **Aquaculture**

The farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants with some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated (FAO, 1989:106)

### **CCP**

A point in the processing steps where the failure to effectively control a potential hazard may create an unacceptable risk (Lee and K S Hilderbrand, 2005:5)

### **Chilled**

Cold (less than +5°C), but not frozen (AFGC, 1999:8)

### **Cold Chain**

A series of interdependent operations engaged in manufacturing, transporting, storing, retailing and serving refrigerated food (AFGC, 1999:8)

### **Diffusion**

The process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 1983:5)

<b>Diffusion (IT Implementation)</b>	Viewed from a technological diffusion perspective, IT implementation is defined as an organisational effort directed toward diffusing appropriate information technology within a user community (Cooper and Zmud, 1990:124)
<b>Food Hazard</b>	A biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect (WHO, 2006:1)
<b>Food Regulation</b>	Actions by government which affect the safety or quality of, or the information available in relation to food; encompassing all types of government regulation making, industry self-regulation, compliance and enforcement activities; and covering relevant activities of all businesses in the supply chain (Food Regulation Review Committee, 1998:26)
<b>Frozen</b>	Food at a temperature of less than or equal to -18°C (AFGC, 1999:9)
<b>Good Manufacturing Practices (GMP)</b>	The basic principles, procedures and means that are required to create a suitable environment for the production of acceptable quality of food (Rose, 2000)
<b>Integrated Logistics</b>	Integrated logistics is defined as the process of anticipating customer needs and wants; acquiring capital, materials, people, technologies, and information necessary to meet

those needs and wants; optimising the goods – and service-producing network to fulfil customer requests; and utilising the network to fulfil customer requests in a timely way (Bloomberg *et al.*, 2002:6)

## **Logistics**

That part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customers requirements (Council of Logistics Management, 2001: 1)

## **Logistics Management**

Logistics is the process of planning, implementing and controlling the efficient, effective flow and storage of goods, services and related information from point of origin to point of consumption for the purpose of conforming to customer requirements (Lambert *et al.*, 1998:3)

## **Management Logistics**

Logistics is a term that refers to the management of functions that support the complete cycle of material flow: from the purchase and internal control of production materials; to the planning and control of work-in-process; to the purchasing, shipping and distribution of the finished product (Chase *et al.*, 2001:339)

## **Marketing Logistics**

Logistics is the process of strategically managing the acquisition, movement and storage of materials, parts and finished inventory from suppliers through the organisation and its

marketing channels, in such a way that current and future profitability is maximised through the cost-effective fulfilment of orders (Christopher, (1992:XI)

## **Quality**

The satisfaction of customer needs is often called “fitness for use”. Therefore, quality must begin and end with the customer (Luning *et al.*, 2002:8)

## **Quality Applied for Food**

Quality may refer to the degree or standard of excellence, and/or the fitness for purpose, and/or the consistency of attainment of the specified properties of the food (IFST, 1998)

## **Quality Assurance**

The modern term for describing the control, evaluation and audit of a food processing system. Its primary function is to provide confidence for management and the ultimate customer, that is, in most cases the consumer (Gould and Gould, 2001:9)

## **Quality Assurance Arrangement**

An arrangement between the controlling authority and the operator of processing premises with an approved quality system, where company management takes responsibility for ensuring the production of wholesome poultry meat. The controlling authority’s role is to monitor the effectiveness of a company’s approved QA system through an audit program to ensure compliance with the relevant provisions of this Standard (CSIRO, 2005:3)

**Quality Function Deployment  
(QFD)**

An over all concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production (i.e., marketing strategies, planning, product design and engineering, prototype evaluation, production process development, production, sales (Sullivan, 1986:39)

**Perishable**

Something that is easily injured or destroyed. Food that are perishable include frozen produce, meats, seafood, dairy products, fruit and vegetables, horticultural products for example flowering bulbs and fresh flowers plus chemical compounds and photographic materials (SRCRA, 1991:1)

**Potentially Hazardous Foods**

Being foods that may contain food poisoning bacteria and are capable of supporting growth of these bacteria or formation of toxins to unsafe levels to consumers if not stored at suitable temperatures (FSANZ, 2004b)

**Privacy**

No one shall be subjected to arbitrary interference with his privacy as a human right (United Nations, 2006:3)

**Radio Frequency Identification  
(RFID)**

An automated data-capture technology that can



be used to electronically identify, track, and store information contained on a tag (GAO, 2005:2)

**Reduced Space Symbology (RSS)** A relatively new bar code format developed to allow variable information, such as lot codes or best-by dates, to be encoded on grocery items in addition to provide the information necessary for checkout operations, all within a compact bar code label (Zebra Technologies, 2005:4)

**Risk Analysis** The process fundamental to the development of food safety standards (FAO/WHO, 1997)

**Seafood** All aquatic vertebrates and aquatic invertebrates intended for human consumption, but excludes amphibians, mammals, reptiles, and aquatic plants (FSANZ, 2005b:12)

**Serial Shipping Container (SSCC)** An EAN.UCC standard for identifying pallets and cases. The SSCC is an 18-digit number expressed in an EAN.UCC-128 symbology bar code that uniquely identifies the contents of the pallet or case (Zebra Technologies, 2005:9)

**Six Sigma** A strategic approach that works across all processes, all products, and all industries. Six Sigma is a rigorous and disciplined methodology that uses data and statistical analysis to measure and improve a company's operational performance by identifying and

eliminating “defects” in manufacturing and service-related processes (Isixsigma, 2005)

**Standard Operating Procedure  
(SOP)**

A set of written instructions that document a routine or repetitive activity used by an organisation (United States Environmental Protection Agency, 2001:1)

**Supply Chain Management  
(SCM)**

Supply chain is not a chain of businesses with one-to-one, business-to-business relationships, but a network of multiple businesses and relationships. SCM offers the opportunity to capture the synergy of intra-and intercompany integration and management. In that sense, SCM deals with total business process excellence and represents a new way of managing the business and relationships with other members of the supply chain (Lambert, 2001:99)

**Temperature Control for Seafood** A) 5°C, or below if this is necessary to minimise the growth of infectious or toxigenic micro-organisms in the food so that the microbiological safety of the food will not be adversely affected for the time the food is at that temperature; or

B) another temperature – if the food business demonstrates that maintenance of the food at this temperature for the period of time for which it will be so maintained, will not adversely affect

the microbiological safety of the food (FSANZ, 2006b:4)

**Traceability**

The ability to trace the history, application or location of that which is under consideration (ISO, 2000:12)

**Tracing**

The capability to identify the origin of a particular unit located within the supply chain by reference to records held upstream in the supply chain. Units are traced for purposes such as recall and complaints (EAN, 2003:8)

**Tracking**

The capability to follow the path of a specified unit and/or lot of trade items downstream through the supply chain as it moves between trading partners. Trade items are tracked routinely for availability, inventory management and logistics purposes. In the context of this standard, the focus is on tracking items from the point of origin to the point of use (EAN, 2003:8)

## Acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
AEGIS	Australian Expert Group in Industry Studies
AFFA	Australian Government Department of Agriculture, Fisheries and Forestry
AFGC	Australian Food and Grocery Council
AIAG	Automotive Industry Action Group
AIM	Automatic Identification Manufacturers Association
ALA	Australian Logistics Assured Program
ANSI	American National Standards Institute
ANZFA	Australia New Zealand Food Authority
ANZFAAC	Australia New Zealand Food Authority Advisory Committee
ANZFSC	Australia New Zealand Food Standards Council
AQIS	Australian Quarantine and Inspection Service
AQUAPLAN	The National Aquatic Animal Health Plan
ARIB	Association of Radio Industries and Businesses
ARP	Application Requirement Profiles
ASI	Australian Supermarket Institute
ASIC	Australian Seafood Industry Council
ASQAP	The Australian Shellfish Quality Assurance Program
ATIS	Advanced Transportation Information Systems
ATMS	Advanced Traffic/Transportation Management Systems
Auto-ID	Automatic Identification
BRC	British Retail Consortium

BSE	Bovine Spongiform Encephalopathy
BSI	British Standard Institute
BTE	Bureau of Transport Economics
BTRE	Bureau of Transport and Regional Economics
CAC	Codex Alimentarius Commission
CCP	Critical Control Points
CDMA	Code-Division Multiple Access
CEN	Comit European Normalisation
CENELEC	Comit European Normalisation Electrotechnique
CEPT	Comité Européen Postal & Telegraph
CPC	Collaborative Product Commerce
CPGs	Consumer Packaged Goods
CRM	Customer Relationship Management
CSIRO	Commonwealth Scientific and Industrial Research Organisation
C-TAM-TPB	Combined TAM and TPB
CVO	Commercial Vehicle Operations
DAFF	Department of Agriculture, Fisheries and Forestry
DC	Distribution Centre
DFAT	Department of Foreign Affairs and Trade
DOD	Department of Defense
DOTARS	Department of Transport and Regional Services
EAN	European Article Numbering
ECMA	European Computer Manufacturers Association
EDI	Electronic Data Interchange
EHF	Extremely High Frequency

EIA	Electronics Industries Association
EPC	Electronic Product Code
ERP	Enterprise Resource Planning
ETSI	European Telecommunications Standard Institutes
EurepGAP	Euro-Retail Produce Working Group Good Agriculture Practices
FAO	Food and Agriculture Organisation
FDA	Food and Drug Administration
FRDC	Fisheries Research and Development Corporation
FSANZ	Food Standards Australia New Zealand
GAO	United States Government Accountability Office
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GHP	Good Hygienic Practice
GHz	Gigahertz
GIS	Geographic Information Systems
GMP	Good Manufacturing Practice
GPRS	General Packet Radio Service
GPS	Global Positioning System
HACCP	Hazard Analysis Critical Control Point
HF	High Frequency
IATA	International Air Transport Association
ICT	Information Communication Technology
IDT	Innovation Diffusion Theory
IEC	International Electrotechnical Commission

IEEE	Institute of Electrical and Electronics Engineers
IFS	International Food Standard
IP	Intellectual Property
IS	Information Systems
ISM	Industry Scientific and Medical
ISO	International Standard Organisation
IT	Information Technology
ITS	Intelligent Transportation Systems
ITU	International Communication Union
JISC	Japanese Information Standards Association
JIT	Just-in Time
KHz	Kilohertz
LF	Low Frequency
LLP	Lead Logistics Provider
LSP	Logistics Service Provider
MF	Medium Frequency
MHz	Megahertz
MM	Motivational Model
MPCU	Model of PC Utilisation
NIST	National Institute of Standards and Technology
NRC	National Research Council
NRF	The National Retail Federation
OCR	Optical Character Recognition
OECD	Organisation of Economic Cooperation and Development
OOS	Out-Of-Stock

PIRSA	Government of South Australia Primary Industries and Resources SA
RAM	Random Access Memory
REP	RFID Enhancer Proxy
RF	Radio Frequency
RFID	Radio Frequency Identification
RIRDC	Rural Industries Research and Development Corporation
ROA	Return on Assets
ROI	Return on Investment
ROIC	Return on Invested Capital
ROM	Read-Only Memory
RSS	Reduced Space Symbolology
RWTA	Refrigerated Warehouse and Transport Association of Australia
QA	Quality Assurance
QC	Quality Control
QFD	Quality Function Deployment
SCM	Supply Chain Management
SCT	Social Cognitive Theory
SHF	Super High Frequency
SKU	Stock Keeping Unit
SMS	Short Message Service
SOAP	Simple Object Access Protocol
SOP	Standard Operating Procedures
SQF	Safe Quality Food
SRCRA	Shipowners Refrigerated Cargo Research Association



SRD	Short Range Devices
SSA	Seafood Services Australia
SSCC	The Serial Shipping Container
SSOP	Sanitation Standard Operation Procedures
TAM	Technology Acceptance Model
TDMA	Time Division Multiple Access
TMS	Task-Management System
TPB	Theory of Planned Behaviour
TQM	Total Quality Management
TQMS	Total Quality Management Systems
TRA	Theory of Reasoned Action
TTI	Temperature Indicator or Integrators
TTT	Time-Temperature Tolerance
UCC	Uniform Code Council
UHF	Ultra High Frequency
UMTS	Universal Mobile Telecommunication Service
UPC	Universal Product Code
UPU	United Postal Union
USDA	United States Department of Agriculture
UTAUT	Unified Theory of Acceptance and Use of Technology
VHF	Very High Frequency
WHO	World Health Organisation
WTO	World Trade Organisation
WVQMS	Woolworths Vendor Quality Management Standard

## CHAPTER ONE: INTRODUCTION

This research is exploratory in nature, seeking to explore the nature of the adoption of time-temperature monitoring equipment for improving the quality assurance of perishable foods during transportation. This research strives to gain a deep insight of the issues and factors surrounding existing technology and time-temperature monitoring equipment for transport perishable foods, and to gather the views and opinions of supply chain participants regarding their supply chain management decisions.

This chapter provides a summary of the background to this thesis and identifies the research objectives and research questions. It also establishes the contribution this thesis makes to the theory and practice of Information Systems (IS) research in the area of the adoption of time-temperature monitoring equipment for quality assurance of perishable food in transport. The first section of this chapter highlights the limitations of previous research on the adoption of time-temperature monitoring equipment. A review of the literature reveals a lack of published material on the use of time-temperature monitoring equipment for the transportation of perishable food. In this context, this chapter outlines the research objectives and primary research questions addressed by this thesis. This section discusses the scope of this research based on five case studies located in three Australian States. The contributions of this thesis to knowledge and practice in IS research are then presented. This section outlines contributions at the substantive, methodological and theoretical levels. The final section of this chapter presents a review of the thesis structure, outlining the remaining five chapters.

### 1.0 Definitions

Before proceeding, it is necessary to establish two key definitions that will be used throughout this thesis.

#### *Logistics*

“Logistikos” is a Greek word which means to be adept or skilful in calculation, from which the word, ‘logistics’ is derived (CuvIELLO, 2005). A review of the literature in the logistics field indicated that there is no universal definition of logistics (BTE,

2001). Gourdon (2001:1) stated that “logistics is a term that many people have heard of, but few can define”. However, there are some common interpretations of the concept that relate to the moving and handling goods and materials from the point of harvest or production to the end consumers. It includes reverse logistics activities, such as handling of damaged goods, recycling and waste disposal, and product and equipment returns (BTE, 2001). According to Langley (1986), there is an assumption that there exists a universal comprehension that, in general, some or all of these terms refer to a wide ranging set of actions that relate to the movement and storage of product and information, and these actions are conducted in order to realise two common goals:

1. Making available an appropriate level of customer service, and
2. Managing a logistics system that largely conforms to the needs of customers.

Gunasekaran and Ngai (2003) classified logistics into two types: social logistics and corporate logistics. In this research, the understanding of the term logistics follows that from the Council of Logistics Management:

*“That part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customers requirements” (Council of Logistics Management, 2001:1).*

This definition has been selected because it indicates some crucial elements of logistics. That is, it encompasses:

- Effective physical flow of materials,
- Storage of raw materials,
- Related information handling, and
- Management of planning, implementing and controlling.

A crucial component of best practice in logistics management is the concept of participants in the supply chain working together in order to satisfy the long-term requirements of the end customer. Therefore, logistics is best described as a system or

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set of activities rather than an industry (Caves *et al.*, 1987). This reflects the essential nature of logistics – a series of interdependent activities performed by companies from various industries (BTE, 2001). In the view of the Bureau of Transport Economics (BTE, 2001), the scope of logistics activities are:

- Production scheduling;
- Consumption;
- Transport/distribution;
- Warehouse and inventory control;
- Order processing;
- Procurement;
- Packaging and material handling control;
- Demand management;
- Information technology;
- Supply chain management;
- Customs processing;
- Inspection;
- Return processing; and
- Implementation of related government regulations such as standards of product and labelling, health and environmental protection.

### ***Supply Chain Management (SCM)***

Lambert (2001:99) stated that:

*“A supply chain is not a chain of businesses with one-to-one business-to-business relationships, but a network of multiple businesses and relationships. SCM offers the opportunity to capture the synergy of intra and intercompany integration and management. In that sense, SCM deals with total business process excellence and represents a new way of managing the business and relationships with other members of the supply chain”.*

Supply chain management can be seen as being a broad logistics concept that concentrates on the combination of the total material movement from supplier to the

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ultimate consumer. Smock (2003:1) stated that “supply chain management is customer-driven as the supply chain responds as efficiently as possible to customer requirements, and is established in order to meet those requirements rapidly, accurately, with no waste and with zero defects”. Stock and Lambert (2001) also stated that there is a great deal of confusion on the subject of supply chain management and all the elements involved. Supply chain management is viewed by most people as being similar to logistics that includes customers and suppliers. To be successful there is a requirement of the cross-functional combination of crucial business processes within the company and networks that make up the supply chain. The challenge for supply chain managers is in working out how to achieve successful integration between supply chain partners.

A large number of analysts also include reverse flows (returns, disposals, recycling) in the definition of supply chain. “Clearly, the term chain is a simplification of the complex web of suppliers, sub-assemblers, manufacturers, distributors and logistics providers who are the primary actors in managing the physical flows from womb to tomb” (McFarlane and Sheffi, 2003:5). The primitive fundamental beliefs suggest that to be able to achieve the aims of supply chain management, individual companies need to coordinate and integrate their actions with other companies along the material flow in mutually beneficial relationships and concentrate their combined efforts on the end customer (Christopher, 1998).

Logistics in contrast to supply chain management, is the work that is necessary to move and position inventory throughout a supply chain (Bowersox and Closs, 1996). The purpose of integrated logistics is to join and synchronise the total supply chain as a process that is continuous and is crucial to effective supply chain management. Logistics deals with the stream of product and service flows within a supply chain (Bowersox *et al.*, 2002). The focus of supply chain is on crucial business processes, while the focus of logistics is primarily with information and material flow. As a result of this logistics management seeks to keep costs to a minimum while supply chain management seeks to make the greatest possible financial returns (BTE, 2001).

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### ***Radio Frequency Identification (RFID)***

RFID systems consist of electronic devices called RFID tags that can be attached to objects, RFID tag and readers that communicate with the tags via electromagnetic waves (AIM Global, 2000). There are three main types of RFID tags:

1. **Passive tags:** these tags do not have their own power and are read via a reader device that sends and receives an electromagnetic signal. They are much lighter than active tags, less expensive and have a longer operational life. However, passive tags typically require closer proximity to readers, and require higher powered readers. They do not require any maintenance as they consist only of passive, reactive components.
2. **Semi-passive tags:** these tags are similar to passive tags but they have their own power to monitor environmental factors such as temperature, humidity, shock, and are read via a reader device. Semi-passive tags differ from passive tags in that semi-passive tags have a longer read range than passive tags and an active power source.
3. **Active tags:** these tags have their power source and can transmit signals synchronously over long distances. These tags tend to be heavier and more expensive than passive tags and typically have an operational life of more than 5 years, depending upon operating temperatures and battery type (RFID journal, 2003).

RFID technology is often compared to barcode technology to highlight its advantages as a 'next generation' technology. Significantly, RFID is a contact-less system that eliminates the requirement for users to pick up and scan products from cartons or pallets, while maintaining the capacity to identify individual items within multi-pack containers (AIM, 2003). Depending on the system used, RFID also opens up the possibility for real-time stock tracking during transportation that has implications for improving security along the distribution channel, servicing of real time transactions and consignment management. In comparison with barcodes, major advantages of RFID are that they do not require line of sight between tags and a reader in order to be

read, tags can be read through non-metallic materials and multiple tags can be read in quick succession (Jones, 1999, Boxall, 2000).

## **1.1 Background**

The background of this research involves logistics, food safety and quality assurance as well as RFID technology.

The concept of supply chain management was developed at Chrysler Corporation by Thomas Stalkamp in the early 1980s and since then has attracted growing attention within the domain of logistics (Smock, 2003).

The worldwide demand for perishable foods provides an opportunity for the delivery of increased product quality assurance and improved customer service by producers and logistic service providers. There has also been real market pressure for organisations to minimise management costs, maximise customer service and market opportunities (Huss, 1993, Luning *et al.*, 2002). This has arisen as the demand for perishable foods has been increasing internationally, with consumers demanding better quality and higher protein fresh foods (Korolishin, 2003). Many successful companies in these industries have reacted by increasing their extent of cooperation with supply chain partners in cold chains and have developed closer alliances with customers and suppliers (O'Keeffe, 2001).

Fluctuations in temperature, heat and humidity levels during transportation impact directly on food safety, product yield, colour and taste (AGWEST Trade & Development, 1997, FAO, 1998, AFFA, 2001b, University of Maryland, 2002, Meat Inspection Division, 2005, Noonan and McAlpine, 2005). Pre-harvesting and post-harvest handling, storage and transport of perishable food all contribute directly to the quality of product (AFGC, 1999). In order to provide suitable protection for consumers and to facilitate trade it is necessary to have an acceptable level of food quality and safety. The implementation and monitoring of quality assurance measures along the entire food chain is essential to achieving these objectives. Therefore, monitoring the cold chain needs detailed information on the temperature requirements and history of food products (Seafood Network Information Center, 2005). However,

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many supply chain participants consider logistics a “black hole” (Autoscan, 2005). So, while there is visibility when goods are being produced, handled and packaged in factories and stored in warehouses and distribution centres, once these goods leave their physical locations, visibility of their environmental conditions is significantly reduced.

In this context, time-temperature monitoring equipment is being explored as a potential solution to address these problems (Avicon *et al.*, 2005). Time-temperature monitoring equipment allows a wide range of objects, including perishable food, to be identified, traced and tracked, monitored and managed. By enhancing the quality and quantity of information on temperature, humidity, duration and location of perishable foods during transportation, it is anticipated that it will be possible to reduce wastage, improve quality assurance of products, improve shelf life and improve freshness.

## **1.2 Research Problem**

Much of the literature has discussed the use of RFID in retail, logistics and supply chain management. Existing utilisations of RFID have previously focussed on access control, animal tagging, product security, product item tracking, inventory management, the flow of goods in supply chains, and consumer packaged goods (CPGs). Worldwide, the lack of substantive research on the use of RFID in perishable food industry has been problematic (Rice, 2006). The lack of quantifiable benefits to be gained from the use of active RFID technology has been an important issue in perishable food chains. Particularly in Australia, there is a lack of research into how time-temperature monitoring equipment can be utilised in the perishable food industry and the factors that affect the potential to gain benefit from the utilisation of the technology. This thesis develops a conceptual model of time-temperature monitoring utilisation that is grounded in the data derived from five case studies of companies that operate in Australian perishable food industries.

### **1.2.1 Research Objectives**

A review of IS, logistics, food safety and quality assurance, as well as time-temperature monitoring equipment literature indicates that there has been limited Australian research into the utilisation of time-temperature monitoring equipment for

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quality assurance of perishable food during transportation (RIRDC, 2005). The published material lacks an essential body of theory that addresses the utilisation of the technology among perishable food industry particularly within the Australian context. The purpose of this thesis is to contribute to the IS discipline by providing an examination of the practices and intentions regarding adoption of time-temperature monitoring equipment. The research aims to satisfy the following objectives, namely to:

- *To examine the impact of time-temperature monitoring on the quality assurance of the transportation of perishable foods in selected case studies;*
- *To identify the issues of transporting perishable foods in these selected supply chains; and*
- *To develop a model of the benefits of the use of time-temperature monitoring for the quality assurance of the transport of perishable foods in the selected case studies.*

### **1.2.2 Research Questions**

In order to fulfil the research objectives, two main research questions and two subsidiary research questions have been formulated.

The first research question is:

*RQ 1: What is a suitable research framework for determining models of the benefits of using time-temperature monitoring equipment for the quality assurance of supply of certain perishable foods within selected case studies?*

The second research question is:

*RQ 2: What models are appropriate to represent the benefits of using time-temperature monitoring equipment for the quality assurance of supply of certain perishable foods?*

*RQ 2.1 What are implications for logistics managers of the use of time-temperature monitoring equipment to monitor the quality of*

*certain perishable foods during transportation?*

*RQ 2.2 How can logistics managers realise the benefits implied by these models of using time-temperature monitoring equipment for the quality assurance of supply of perishable foods within selected case studies?*

### **1.2.3 Research Methodology**

The research is based on an objective ontology with a post-positivist epistemology, utilising qualitative analysis methods. A multiple case study approach was used encompassing five case studies located in three States of Australia. Semi-structured interviews were conducted with the owners/managers of a range of businesses in the perishable food industry. Face to face interviews were conducted. These interviews were digitally recorded and transcribed to allow detailed analysis. In order to maintain the rigour and transparency of the research, the transcription from each interview was sent to the participants to obtain validating of their correctness. Two data analysis techniques, derived from Miles and Huberman (1984, 1994), were used to analyse the data. The first part of the data analysis was conducted using within a single case study analysis techniques. This approach was particularly useful in uncovering issues and relationships in the data, and assisting in the derivation of interpretations and viable explanations. The second part of the data analysis utilised a cross-case analysis technique, also based on Miles and Huberman (1984, 1994). Within this analysis the similarities were determined by making comparisons between the five case studies.

### **1.2.4 Research Scope**

To be able to deal with the research questions, there was a need to select suitable case study participants. An important consideration was the choice of methods employed for the collection and analysis of the data. In this section, various aspects of the research scope are discussed:

- Selection of the participants;
- Location of the participants;
- Data collection methods; and
- Techniques used for data analysis and interpretation.

### ***Selection of the Participants***

Initially, finding a selection of perishable food industries actively engaged in the utilisation of time-temperature monitoring equipment was a difficult task. This can be attributed to the fact that the adoption of time-temperature monitoring equipment for quality assurance of perishable food is not yet widespread, both in Australia and worldwide.

### ***Location of the Participants***

Five case studies were selected from three states in Australia. A total of two case studies from Tasmania, two from Sydney and one from Melbourne were included in the study. These five cases studies represent a varied collection of perishable food industry contexts that involved red meat, seafood, dairy and confectionary food. Participants were selected on the basis that they were involved in the processing and distribution of perishable foods and they had knowledge of the use of active RFID technology for time-temperature monitoring of the transportation of perishable food.

Within each identified company the general manager, logistics manager, or quality assurance manager was approached in that order to gain their consent to be involved in the study. In some cases one person performed all of these roles.

### ***Data Collection Methods***

Face-to-face interviews with owners/managers were conducted in each case study. A semi-structured question framework was employed to gain information about the participants' experiences and views concerning the utilisation of time-temperature monitoring equipment for the transportation of perishable food. The question framework gathered details about:

- Business background;
- Current issues with transportation of perishable food and quality assurance standards of products;
- Experience with time-temperature monitoring equipment;
- Impact and changes to the business as a result of using time-temperature monitoring equipment; and

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- Any problems that have been incurred from the utilisation of time-temperature monitoring equipment.

### ***Techniques Used for Data Analysis and Interpretation***

Each interview was transcribed to support the analysis of the data. A series of coding procedures was adapted from other accepted text analysis practices (Glaser and Strauss, 1967) and were applied to simplify and manage the individual case data. The data were then analysed using qualitative data analysis techniques, called *within a single case study* and *cross-case analysis*, described in Miles and Huberman (1984, 1994). This technique proved to be useful in uncovering issues and relationships in the data and assisting in the derivation of interpretations and viable explanations for each case study.

Eight causal diagrams (Miles and Huberman, 1994) were developed to assist in the interpretation of the data and to depict the relationships between the identified dependent and independent variables. Each of the nodes in these networks represent a concept that has been identified by the participants as a key issue in the time-temperature monitoring of products through out the supply chains. The links in these networks represent causal relationships between pairs of concepts. The identification and labelling of each of the concepts and relationships in these networks have been closely derived from the coded transcripts of the interviews in the five case studies.

## **1.3 Contributions: Theoretical, Methodological and Substantive**

This research contributes to a better understanding of the nature of the time-temperature monitoring equipment of the transport of perishable foods. While this research is exploratory, it seeks to develop a series of models that characterise the relationships between independent and dependent variables that have been identified in the five case studies. No claims are made to the generalisability of these models beyond the case studies presented and analysed. Rather, the major contribution of this research is the development of models that can form the basis for further explanatory and confirmatory research in this field.

### 1.3.1 Theoretical Contributions

This research develops a framework that explores the benefits of adopting time-temperature monitoring equipment for the quality assurance of perishable food throughout supply chains. This research makes a number of contributions to theoretical knowledge:

- The identification of independent and dependent variables that characterise the determination of benefits in the adoption of time-temperature monitoring equipment for quality assurance of perishable food;
- The identification of the development of a theoretical framework for further research into time-temperature monitoring equipment; and
- The establishment of a foundation body of research that can serve to promote and motivate research attention in seeking to understand the benefits of active RFID especially in perishable foods.

### 1.3.2 Methodological Contributions

An important aspect of the research methodology and of the approach taken by the researcher to the qualitative analysis was the acceptance of pluralism, both in terms of the applicability and rigour of several analysis techniques and of data display schemes (Miles and Huberman, 1984b, Hirschheim, 1985, Miles and Huberman, 1994), and of the acceptance of multiple concurrent interpretations and explanations of the phenomena, issues and relationships identified in the data (Phillips, 1990, Fischer, 1998, Patomaki, 2000, Trochim, 2002a, Demetrion, 2004, Myers *et al.*, 2004).

The methodological contributions of the thesis are:

- A demonstration of the application of qualitative analysis in a post-positivism epistemology to the understanding of phenomena for which there is a very restricted data set; and
- A demonstration of an approach to the application of the principles of within a single case study qualitative analysis techniques, using a post-positivist epistemology described in Miles and Huberman (1984, 1994).

### **1.3.3 Substantive Contributions**

The models developed in this research also provide a practical resource for organisations. They will provide insight into the cause and effect relationships associated with the adoption of time-temperature monitoring equipment and allow comparisons that may be naturally generalised to other perishable food industries. Use of this information could prove particularly beneficial when used as a benchmark to analyse normative models of the use of time-temperature monitoring equipment within specific business sectors. For organisations, another important aspect of this study is the determination of how organisations seek to achieve benefit from time-temperature monitoring equipment, and also the justifications for decisions to adopt time-temperature monitoring equipment within their organisations. It is proposed that the present research will offer:

- Increased understanding of the roles that time-temperature monitoring equipment can play in quality assurance in the transport of perishable foods;
- Development of models that form the basis for the development of ROI implication on an individual supply chain business of the adoption of time-temperature monitoring for quality assurance of perishable food; and
- Eight case-based models of time-temperature monitoring equipment utilisation and business transformation reflecting the influence of internal and external factors.

### **1.4 Structure of Thesis**

This section provides a summary of the remaining chapters in this thesis. In keeping with the post-positivism research approach, apart from the last chapter, each chapter concludes with a section providing a summary reflection on the contents of the chapter.

The thesis consists of five chapters. In the introductory chapter the background, theory and framework are identified and the questions approached in the chapter are presented. This opening chapter has provided a background to support the identification of the perceived research problem to be addressed in this thesis. From

this the research objective and research questions have been developed. Finally, the proposed contributions that may result from this research have been identified.

## **Chapter 2: Literature Review**

Chapter Two provides a critical review of the existing body of knowledge as found in the literature pertinent to the research. The chapter identifies a number of interrelated conceptual and practical concerns arising from research in the transportation of perishable foods, food safety and quality assurance, technological developments and RFID technology. The outcomes from Chapter Two will then be applied to determine the theoretical background, perspective, scope and approach for this research.

## **Chapter 3: Research Methodology**

Chapter Three of the thesis describes the research methodology used to conduct the study.

## **Chapter 4: Data Analysis**

Chapter Four provides an in-depth explanation of the analysis of the data that emerged from the primary investigation. The data collected were primarily qualitative in nature. Consistent with the reflective process adopted throughout the research, Chapter Four seeks to describe and make explicit the analysis. This chapter provides an overview of the five case studies.

## **Chapter 5: Findings**

Chapter Five provides an interpretation and discussion of the analysis of the complete dataset. The findings of the data are developed using the analysis techniques established in Chapter Four.

## **Chapter 6: Conclusion**

Chapter Six presents the conclusions of this study. A review of all major findings is discussed along with an outline for future work in this emergent research area.

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.0 Introduction**

This chapter presents an overview of the literature related to the research in this thesis: adoption of time-temperature monitoring technology in the transportation of perishable foods. Due to the novelty of the technology, the bulk of the literature focuses on a practitioner perspective rather than an academic one. Little evidence could be found that has reported on the adoption of time-temperature monitoring technology from an economic perspective that is relevant to the perishable food industry.

### **2.1 Logistics**

In this section the following aspects of logistics will be examined:

- Evolution of the concept of logistics;
- Logistics activities and expenditure; and
- Logistics in Australia.

#### **2.1.1 Evolution of the Concept of Logistics**

This section will introduce the concept of logistics from both traditional and present day perspectives.

A number of business logistics theories have been developed since the Second World War and there have been many changes in the concept of logistics over the last two decades (Bowersox, 1983, Bowersox and Closs, 1996, Lukka, 2005). The idea of logistics goes back to its early use by the military during the Second World War (Vetschera, 2005). Slack *et al.*, (1999) noted that it related to the military having a need to move and coordinate troops and their arms to various locations. According to Bowersox (1978), it was not until the 1960's that business logistics was an academic subject, when some researchers employed logistics application for use in business activities. DOTARS (2002) reported that in the mid-1980s a vital part of logistics, which is the trade-off between transport and inventory costs, was recognised in a formal manner in economics.



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The theory of logistics was initially developed for special functions, for example, production, inventories, and transport (Christopher, 1993). Later it was necessary to combine these, as it became apparent that the concept of logistics needed to encompass all functions. The term “physical distribution management” began to appear in the 1960s. It implies the total movement of goods downstream from the plant to the consumers (Bowersox, 1983). After the economic recession period during the 60’s there was a need for an alternative view of materials management and it was during this time that the material logistics management concept was developed (Bowersox, 1983).

Langley *et al.*, (1988) predicted that logistics would concentrate more on quality management, with time and space being jointly unified with logistics attributes and not specific logistics services. In addition to this there were a dramatic increase of available opportunities in international logistics, the appearance of third-party companies that could manage the whole logistics function, and the need for education in logistics concepts (Langley, 1986). The traditional view of logistics was certainly the provision to companies of time and space utilities. The organisational functions delegated to the creation of these utilities were warehousing and transport (Caputo and Mininno, 1998). Lukka (2005) stated that logistics theory had its base in the practical management of logistics and was based on the ideal manner of managing logistics.

### ***Traditional Logistics:***

The adoption of new logistics systems was relatively slow and costly. The cumulative effect was masked due to the incremental nature of the problem, and the fact that cross-functional activities like logistics, as a rule, lacked a voice in top-management (Sharman, 1984).

Essential parts of competitive success, in the current era of shrinking product life cycles, are just in time manufacturing (JIT), proliferative product lines, modern material handling, shifting distribution chains and the ready adoption of changing technology (Bowersox, 1983). Chiu (1995) identified the key success factors in effective logistics management as:

- Good quality planning of the logistics systems;

- Well designed distribution organisation;
- Careful selection of allied companies;
- Close relationship with trading partners;
- Good logistics investment analysis;
- Removal of any barriers to logistics management;
- Top management commitment; and
- Continuous improvement.

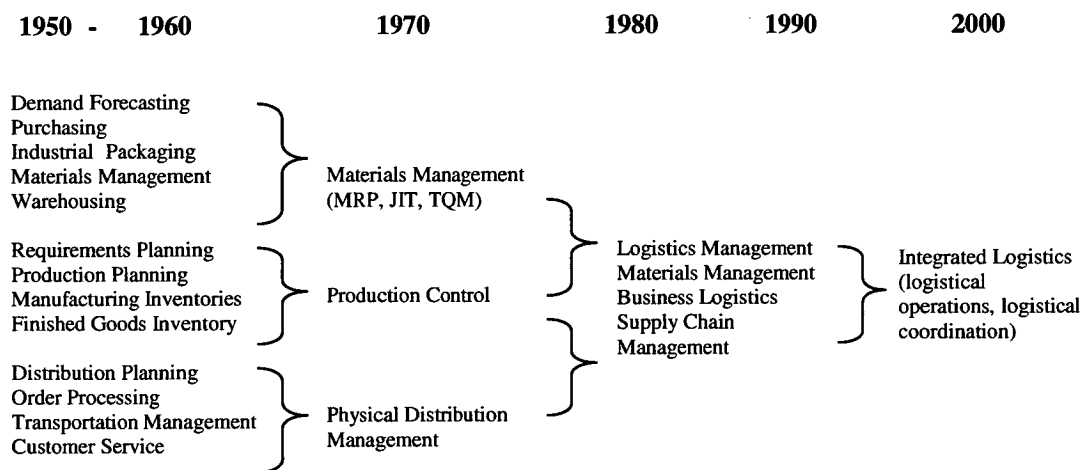
The realisation of the need for integrated logistics systems is one of the most important developments in the last twenty years (Bloomberg *et al.*, 2002). The trend towards the development of partnership arrangements with vendors, customers and logistics service providers/outsourcing parties such as third parties logistics (3 PL) and fourth parties logistics (4 PL) has also been one of the ways in which logistics systems have become more integrated (Lukka, 2005). Bloomberg *et al.*, (2002) stated that all activities of a logistics nature need to work as one in order to transport the product smoothly from dispatch to the final customer. The fact that an increasing amount of companies have taken on a “total channel” perspective in their businesses clearly defines and supports this trend. Businesses have also developed linkages with their supply chain participants (Langley, 1986). In the logistics literature, it is generally recognised that to achieve improved logistics services there must exist growing cooperation and collaboration between companies within a supply chain (Bowersox and Closs, 1996, Edwards *et al.*, 2001, Stank *et al.*, 2001). To illustrate this, Lamming (1995) stated that there is a need for companies to seek strength outside the traditional boundaries of their company by collaborating with other companies.

### ***Present Day Logistics:***

There has been a dramatic change in the scope and role of logistics over time (Bowersox and Closs, 1996, Titone, 1996, Gunasekaran and Ngai, 2003, Lukka, 2005). Historically it played a supportive role to primary functions, for example, marketing and manufacturing. However, it has now expanded to include warehousing and transportation activities. It also covers purchasing, distribution, inventory management, packaging, manufacturing, partnerships, strategic

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alliances, and customer service. There has been an evolution in logistics from a passive, cost absorbing function, to a critical factor of competitive advantage, establishing its importance in enabling companies to go global and access foreign markets (Bovet, 1991, Christopher, 1993, Bowersox and Daugherty, 1995, Bowersox and Closs, 1996, Olavarrieta and Ellinger, 1997, Bowersox *et al.*, 1999, Lynch *et al.*, 2000, Sum *et al.*, 2001, Zhao *et al.*, 2001, Bloomberg *et al.*, 2002, Gunasekaran and Ngai, 2003). Organisations now have the ability to realise an increase in production, to source efficiencies and to tap technological competencies beyond their geographical borders (Fawcett *et al.*, 1993). Figure 2-1 provides a summary of the evolution of logistics from multiple fragmented processes in 1950s to the present day fully integrated approach.



**Figure 2-1. A Summary of the Logistics Evolution**

Source: an adaptation from (Dansk, 2007)

In regard to competitive advantage, the strategic implication of information technology has acted as a primary business subject since the 1980s (Closs and Frankel, 1992, Closs *et al.*, 1997). Many authors have promoted information technology as a tool to improve the competitiveness of logistics (Parsons, 1983, Porter, 1985, Porter and Millar, 1985, Stenger, 1986, Kerr, 1989, Stock, 1990, Introna, 1991, Daugherty, 1994, Bowersox and Daugherty, 1995, Daugherty *et al.*, 1995, Bowersox and Closs, 1996, Closs *et al.*, 1997). The source of competitive advantage is in the capability of the organisation to differentiate itself, in the consumer perspective, from its competition, and to operate at a lower cost with high quality, and therefore operate more profitably than its competitors. By

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discretely designing, producing, marketing, delivering and supporting its products, an organisation can gain a competitive advantage (Porter, 1985). Lukka (2005) stated that across company borders visibility will be the key strategic point in the management of logistics.

Lambert *et al.*, (1998:76) noted that “computer and information technology has been utilised to support logistics for many years. Information technology is seen as the key factor that will affect the growth and development of logistics”. The flow of information has been identified alongside the importance of materials flows in the logistics channel (Closs *et al.*, 1997, McMeekin *et al.*, 2004, Sensitech, 2004). Rushton (2001:5) extended the idea of Lambert *et al.*, (1998) by saying that “without the smooth flow and transfer of information it is impossible for a distribution system to function adequately and effectively”. Introna (1991) demonstrated that the logistics system turns materials into products, creating value for customers and the information system turns data into information to assist the decisions of managers. Hepworth (1990) used information geography as a tool to link computer network innovations to production processes. Stock (1990) also discussed the successful communications and information systems in a warehousing context where information serves as an alternate for inventory.

There has been a minimisation of country trade barriers and this, coupled with the advent of advanced information technologies, has opened up new opportunities and global markets to companies (Closs *et al.*, 1997). There is a reliance on logistics to move products and materials in order to meet new production requirements and the needs of customers (Gunasekaran and Ngai, 2003). A key determinant of current business performance is the role of the logistics function in ensuring the smooth movement of materials, products and information through the supply chains of a company (Sum *et al.*, 2001). Mentzer *et al.*, (2004:616) stated that “logistics information management capabilities meet the supply chain operational and strategic information needs to balance supply and demand and facilitate supply chain exchanges, which leads to optimisation of system-wide capital investment, which leads to competitive advantage”.

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The trend toward the development of partnership arrangements with vendors, customers and external third parties is a result of logistics information systems becoming more integrated. Research by Maynard *et al.*, (2002) acknowledged that there is a need for the new logistics environment to work in co-operation with other enterprise-class solutions such as Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Customer Relationship Management (CRM), and Collaborative Product Commerce (CPC). Lukka (2005) stated that outsourcing has forced subcontracting to play a bigger role. As a result quality considerations concerning both services and products have become an essential practice.

In order to achieve this coordination, integration of all the links in the supply chain ICT is critical. Recent technological developments in this field have the potential to facilitate this coordination, and allow for virtual integration of the entire supply chain (Chiu, 1995, Bowersox *et al.*, 1999, Alshawi, 2001, Zhao *et al.*, 2001, Gimenez and Lourenco, 2004). Porter and Millar (1985) acknowledged that there is evidence that logistics companies will need to keep abreast of the information age in order to improve their market standing. With the growth of ICT, managing the flow of information has become as important as managing the flow of material in the supply chain network (Sarkis *et al.*, 2004, Vetschera, 2005). Further it is now commonly accepted that the correct implementation of ICT can be a good source of competitive advantage to companies (Lukka, 2005). Closs and Xu (2000) viewed that this is particularly so for the logistics industry as a result of its dependency on information for efficient operations. The use of technology potentially assists in reducing logistics costs, in addition to reducing the risk of damage of the goods in transit, and increasing the speed, security and reliability of delivery.

The advantages of ICT in increasing the leverage of innovation in logistics and supply chain management have been noted by various authors (Langley *et al.*, 1988, Kerr, 1989, Vetschera, 2005). Christopher (1998) noted logistics is a cross-functional process that cuts across the functional boundaries of an organisation in its focus in the supply chain. This recognises the complexities of synchronising the movement of information between business processes. In addition to this,

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product development and delivery cycles are not as long as previously. Customers and distributors have the habit of taking for granted JIT deliveries and end users are now more willing to accept a substitute product in the case where their first choice is not immediately available. The application of ICT is an efficient way of enhancing the company's strategic significance and operational effectiveness has been considered by (Langley *et al.*, 1988, Christopher, 1998). Both Langley *et al.*, (1988) and Christopher (1998) adopted the view that managers should initially look at the overall business needs before making up their minds as to what ICT hardware or software is appropriate. The result of the project was the deployment of an ICT system to monitor and control the flow of inventory (Christopher, 1998). The ability of these systems to assist in logistics planning and control has been shown (Langley *et al.*, 1988, Christopher, 1998). Further, computer technology has become more and more linked to the planning, implementation and control of traditional inventory activities, such as product receipt, storage, order picking, and shipping.

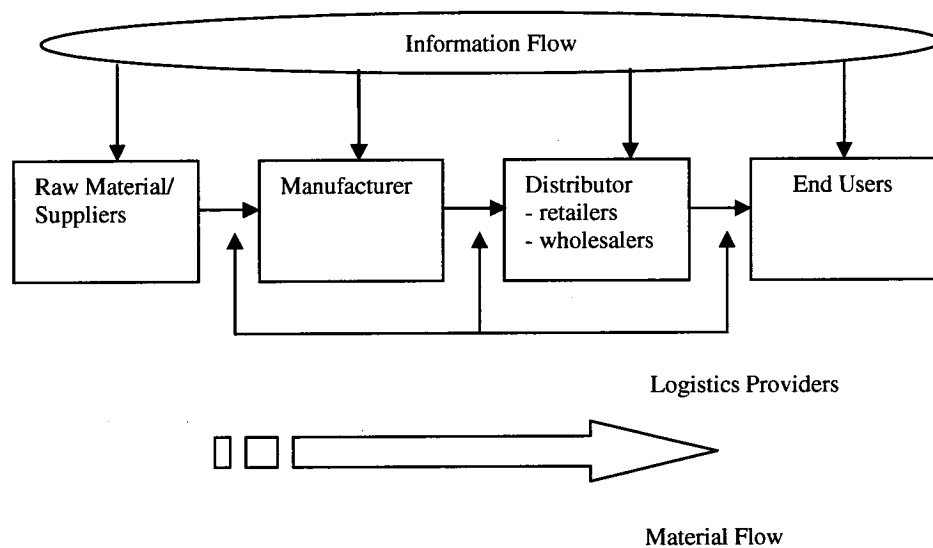
In a similar vein, Kerr (1989) stressed how logistics IT has the ability to contribute to the overall strategy of the company. Closs *et al.*, (1997) offered strong evidence that innovative use of IT capabilities influence the overall logistics competency of a company. Londe (1973) identified that such technology was moving from being an enabler of operational and material handling functions, to becoming an enabler of decision making and activity-planning functions within the transportation and distribution areas of the supply chain. It was observed that, with the ability to reduce the costs of warehousing, many companies were able to gain competitive advantages, by routinely using ICT in their warehouse operations (Stock, 1990, Rabinovich *et al.*, 1999).

The goal of logistics management is to link the marketplace and operations in such way that the service provided to customers is of highest level with minimal cost. Increased sales and a greater share of markets for a firm can be also be obtained by companies that employ such a system (Novack, (1989b).

Figure 2-2 demonstrates the flow of logistics across a supply chain. The material flow represents the supply of products through the network in response to the

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demand from supply chain partners. The information flow is not a process, but a key enabler of supply chain integration (Stock and Lambert, 2001). Today the information flow within the logistics has become vital as this flow enables chains to respond in real time with accurate data. There are strong links between the physical flow and the information flows, both upstream and downstream (Stair and Reynolds, 2003). Maynard *et al.*, (2002) identified that the flows along supply chains are monetary, information, materials and resources. The initiator for both the monetary flow and the material flow is the information flow.



**Figure 2-2. A Typical Logistics View**

Source: an adaptation from Lawrence *et al.*, (2003)

Christopher (1998) proposed that the needs of customers may be satisfied by coordinating the materials and information flows that go out from the marketplace, through the operational environment of the company, and finally, to the suppliers. Further the focus of logistics management is to optimise flows within the organisations and to have an integrated plan for the flow of product and information along the supply chains (Christopher, 1998). According to BTE (2001), the efficient and effective operation of logistics systems is dependent upon information flows that are reliable, timely and involve both providers and users of the services.

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### 2.1.2 Logistics Activities and Expenditure

Developing and maintaining flexible and responsive logistics networks are critical to the survival of companies and consequently, the future competitiveness of logistics networks and the continued survival of the entities within them. DOTARS (2002) stated that the evolution of logistics activities has been in response to changes, such as globalisation, general industry restructuring, new production processes, and technological advances. DOTARS (2002) also pointed out that efficient and effective logistics are accepted as being essential to a company's competitive position. The importance of logistics policy in improving national competitiveness is being recognised by national governments (DOTARS, 2002). In the view of Maynard *et al.*, (2002) maximising logistics's operational economies, predictability, and effectiveness relies on the availability of accurate and up-to-date logistics information to all sides of enterprise operations, from sales and marketing, to manufacturing, to supply chain managers.

According to Lukka, (2005), logistics is one of the vital areas that can distinguish business success. Logistics is increasingly being recognised as having a significant impact upon economic value added and therefore, increased shareholder value (Christopher, 1998). Logistics costs are driven or created by the activities that support the logistics process (Lambert *et al.*, 1998). The Service Industries and Capital Projects Branch (2000) have stated that efficient logistics practices shorten the amount of time that is needed to get goods from the supplier to the customer. Maynard *et al.*, (2002) have reported that logistics service operators have to also become global, and offer a broad range of services. Between 10 percent and 13 percent of a developed country's gross domestic product (GDP) can be accredited to logistics-related costs for the transportation of parts, components, and finished goods between suppliers, manufacturers and customers. In monetary terms this comes to more than \$4 trillion that has been spent on logistically logistics globally. This is a cost that has for a time been viewed as the "cost of doing business" (Maynard *et al.*, 2002).

Stock and Lambert (2001) cited in Bowersox (1978), expressed the view that the basic integrative concept in logistics design is total-cost analysis. One of the



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major goals of the organisation should be the reduction of the total costs of logistics actions rather than concentrating on individual activities in isolation (Lambert and Armitage, 1979, Harper, 1982). By reducing one cost, there will be increases in the costs of other components. Effective management and real cost savings can be achieved only by seeing logistics as an integrated system and attempting to minimise its total cost given the company's customer service objectives (Lambert *et al.*, 1998, Stock and Lambert, 2001). Lambert and Armitage (1979) stated that at different levels of activity, costs move in different directions.

In the literature, there is little agreement as to the specific cost categories to be included in total cost analysis (Kenderdine and Larson, (1988). They both noted that while Lekashman and Stolle (1965) considered ten cost elements in their expressive article, Amstel (1985) included six cost centres in physical distribution cost control. Bowersox (1978) proposed three types of specific expenditures involving direct, indirect, and overhead. Lambert *et al.*, (1998) identified six major cost categories involved place/customer service cost, transportation costs, warehousing costs, order processing and information costs, lot quantity costs and inventory carrying costs. However, Harper (1982) presented nine components of the total cost. These are transportation, warehouse operation, inventory management, production scheduling, materials handling, packaging, order processing and information systems, plant and warehouse location and customer service.

Ballou (1987) defined three primary activities for logistics as being transportation, inventory maintenance and order processing. However, Bowersox (1978) proposed five major components combine to form the logistics system involved facility location structure, transportation, inventory, communication and handling and storage. Bowersox *et al.*, (2002) acknowledged five areas of logistics system involved order processing, inventory, transportation, warehousing, materials handling and packaging and facility network. Table 2-1 provides a range of logistics areas, logistics activities and logistics cost. It highlights that cost is an often repeated theme in much of the logistics research.

**Table 2-1. A Summary of Logistics Activities**

<b>Logistics Areas</b>	<b>Logistics Activity</b>	<b>Logistics Cost</b>
<b>Customer Service</b>	Output of the logistics system; getting product to the right customer at the right place, in the right condition and at the right time, at the lowest total cost possible	Order fulfillment, parts, service support and the cost of returned goods handling. The key cost trade-off associated with varying levels of customer service is the cost of lost sales
<b>Demand Forecasting/ Planning</b>	Forecasting in terms of how much should be ordered from its suppliers, and how much of the finished product should be transported or held in each market that the organisation serves	Stock monitoring, warehouse management, gathering and processing of transaction data and other market intelligence
<b>Inventory Management</b>	The aims of inventory management are to make corporate profitability greater to foretell what the impact of corporate policies are on inventory levels, and to keep as low as possible the total cost of logistics activities	Four major categories of inventory cost are capital cost or opportunity cost, inventory service cost, storage space cost and inventory risk cost
<b>Logistics Communications</b>	Excellent communications within a system can be a key source of competitive advantage	ICT infrastructure, information systems architecture
<b>Materials Handling</b>	All aspects of all movements of raw materials, work in process, or finished goods within a plant or warehouse	Operations and capital expenditure
<b>Order Processing</b>	Receive orders from customers; check on the status and communicate with customers regarding orders; as well as actually filling the order and making it available to the customer	Include order transmittal, order entry, order verification, order handling, and related internal and external costs such as notifying carriers and customers of shipping information and product availability
<b>Packaging</b>	Advertising, promotion, marketing, protection and storage for goods. Packaging can convey important information to inform the consumer and attract the consumer's attention	Packaging design, operations and capital expenditure, reverse logistics of disposal or recycling
<b>Parts and Service Support</b>	Enhance the attractiveness and reputation of a firm and its products	Custom service and port warehousing
<b>Plant and Warehouse Site Selection</b>	Determining the location of the company's plant (s) and warehouse (s) is a strategic decision that effects not only the costs of transporting raw materials inbound and finished goods outbound, but also customer service levels and speed of response	Real estate, capital expenditure, capital depreciation
<b>Procurement</b>	Purchase of materials and services from outside organisations to support the company's operations from production to marketing, sales and logistics	The cost of purchased materials and supplies is a significant part of total expenditure in most organizations

<b>Salvage and Scrap Disposal and Return Goods Handling/ Reverse Logistics</b>	Recycling and reusable packaging becomes more and more an important issue and given the complexity and high costs associated with return goods handling. Reverse logistics also include processing returned goods due to damage, seasonal inventory, restock, recalls and excess inventory. It also includes recycling programs, hazardous material programs, obsolete equipment disposal, and asset recovery	Reverse logistics operations and monitoring, compliance with relevant regulations
<b>Traffic and Transportation</b>	Managing the movement of products and includes activities such as selecting the method of shipment, choosing the specific route (also known as routing), complying with the transportation regulations on local, provincial and national levels and having a knowledge of shipping requirements both locally and internationally	Transport is generally the largest single component of logistics costs. Most supply chain activities, roughly 80 percent of the cost is with the transportation, while with 20 percent going to costs associated with warehousing and cross-cocking
<b>Warehousing and Storage</b>	It plays a key role in satisfying customers' needs with a suitable level of customer service at the lowest possible cost. Warehousing therefore supports the time and place utility of goods by allowing an item to be produced and held for later consumption	The result of warehousing and storage activities and by the plant and warehouse site selection process

Source: an adaptation from (Bowersox, 1978, Lambert *et al.*, 1998, Rogers and Tibben-Lembke, 1998, Milligan, 2000, Service Industries and Capital Projects Branch, 2000, BTE, 2001, Rushton *et al.*, 2001, Stock and Lambert, 2001, Bowersox *et al.*, 2002, Coyle *et al.*, 2003)

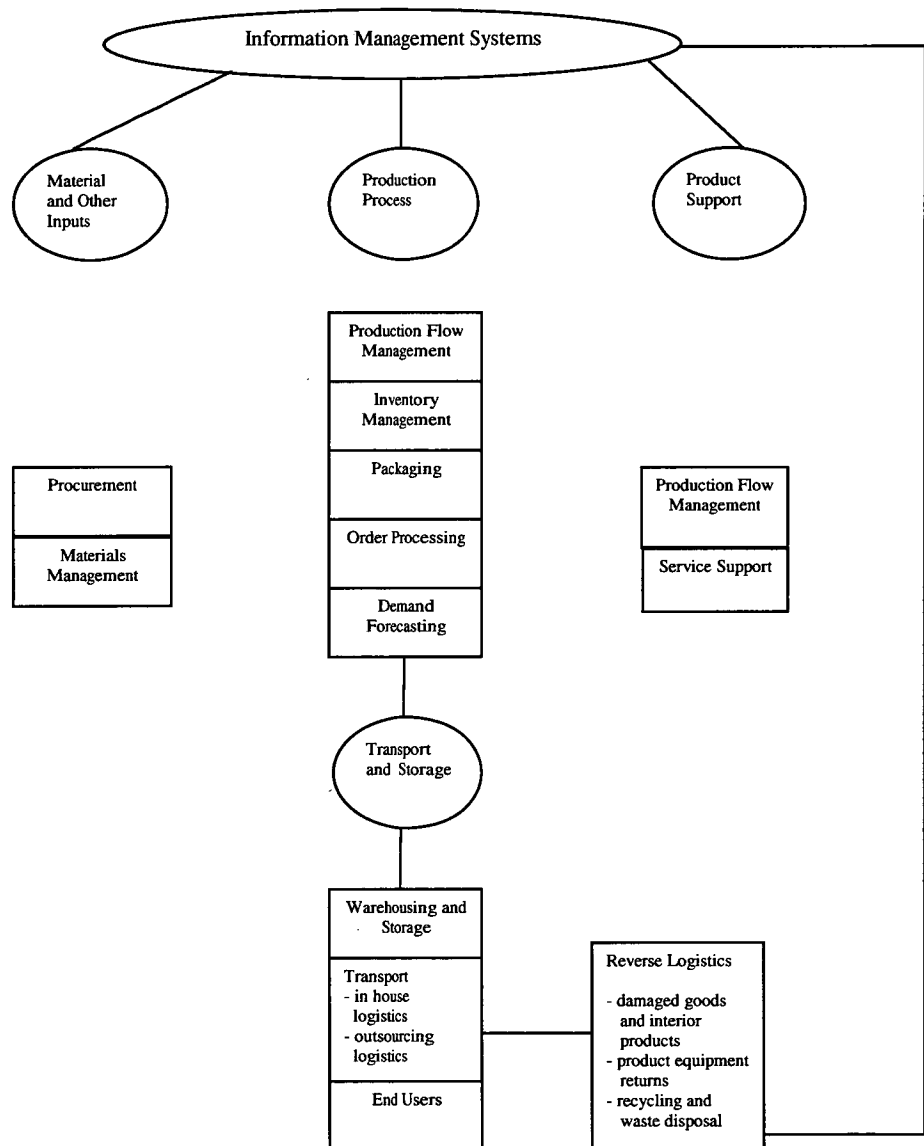
BTE (2001) have identified production process as an additional logistics activity. This process was seen as being a core function of a company, often conducted in-house. According to BTE (2001), this encompasses the following issues:

- Production flow management;
- Inventory management;
- Packaging;
- Order processing; and
- Demand forecasting.

Further Service Industries and Capital Projects Branch (2000) have also classified customs clearance (customs brokerage) as a logistics activity.

Figure 2-3 gives an overview of a logistics system. It shows that logistics services aid the movement of materials and products from inputs through production to consumers and also to associated waste disposal and reverse flows. Included in

this are activities undertaken in-house by the users of the services and the functions of external service providers. In addition to physical activities (transport, warehouse), logistics services comprise non-physical activities (supply chain design, selection of contractors, freight rate negotiation).



**Figure 2-3. Logistics Activities**

Source: an adaptation from BTE (2001)

### 2.1.3 Logistics in Australia

This section considers logistics activities in Australia. There are few studies available concerning the performance of the Australian freight logistics sector. A primary source of data for freight logistics is the ABS (DOTARS, 2002). There is

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also limited evidence of logistics research in Australia (Gilmour, 1993, Gilmour *et al.*, 1994, Dapiran *et al.*, 1996, Millen and Maggard, 1997, Strategic design Development, 2004, Mollenkopf and Dapiran, 2005). However, a fairly good approximation can be made of the value of the Australian logistics market by determining how much was spent by the Australian business community on outsourced logistics services and how much the resources were used to perform logistics operations in-house (Strategic design Development, 2004).

Table 2-2 presents the logistics costs in Australia. These figures were the most recent available at the time of writing this thesis.

In 1999-2000 the total transport logistics cost was \$139 billion which was equivalent to 22 percent of Australia's GDP, whereas in 2002-2003 it was \$166 billion. In-house logistics costs increased by \$10 billion from 1999-2000 to 2002-2003, whereas outsourcing logistics costs were the same in both years. Services supplied by freight transport logistics operators added up to \$41 billion, while the service provided by non-transport logistics operators came to about \$39 billion in 2002-03. This makes the freight logistics sector one of the biggest players in the Australian economy (DOTARS, 2002). However, this is not representative of the total worth of the Australian market, because the value-added contribution is only a proportion of operating revenue, as the BTRE observation in its port impact studies is that there is a possibility of revenues being 1.6 times value-added (BTE, 2001). There has been a prediction that the general logistics task will double, in terms of the amount of freight moved, before 2020 (Auslink, 2005).

**Table 2-2. Australian Logistics Costs**

<b>Component</b>	<b>AU \$ billion</b>	
	<b>1999-00</b>	<b>2002-03</b>
<b>Outsourced Transport</b>	33	39
Road Transport	17	20
Transport Services	12	14
Rail Transport	3	4
Maritime Transport	1	1
Air Transport	1	1
<b>In- house Transport</b>	23	27
In-house Road Transport	17	20
In-house Transport Services	6	7
<b>Total Transport Costs</b>	56	66
<b>Total Logistics Costs</b>	139	166
Transport (40%)	56	66
Storage (25%)	35	41
Inventory (20%)	28	33
Administration (15%)	21	25
<b>Realised Logistics Market</b>	34	41
Outsourced Transport	33	39
Outsourced Non-transport (storage)	1	2
Outsourced logistics service as a proportion of total logistics costs	25%	25%
<b>GDP</b>	629	754
Total logistics costs relative to GDP	22%	22%

Source: (Strategic design Development, 2004: 11)

Gilmour *et al.*, (1994) identified six key issues that influence the nature of Australian corporate logistic operations: environmental pressures, shifting power in the logistics channel, technology, the global marketplace, outsourcing options, and cycle time to market. In addition BTE (2001) determined the logistics issues in Australia as:

- Lack of good communication between logistics chain participants;
- Inadequate infrastructure;
- Unavailability of uplift space;
- Inflexibility in quarantine arrangements; and
- Availability of data.

The level of interest in logistics in Australia has increased rapidly (Millen *et al.*, 1997). Logistics management in Australia has had a slow acceptance by the local business community as a legitimate functional activity that can both improve customer service and the bottom line (Gilmour *et al.*, 1994). Logistics represents

an important role in Australia due to the fact that is a tendency of populations to be concentrated in a small number of metropolitan centres. The rest of the population is spread out over the entire country which has created small areas of population that are in need of transport services (Dapiran *et al.*, 1996). This means that vast distances need to be covered in order to transport products to small towns (Mollenkopf and Dapiran, 2005). According to BTE (2001), cost structures, revenues, service quality, and competitiveness in the Australian industry is heavily effected by the performance of the logistics systems. One of the reasons for this heightened interest by Australian companies is the increase in export activity, especially into Asian markets (Millen *et al.*, 1997).

The outsourcing of logistics activities has been a business dynamic of increasing importance in Australia (Dapiran *et al.*, 1996). In Australia, most freight transport activity is performed by logistics service providers; while most non-transport activities are performed or managed in-house by the companies (DOTARS, 2002). Future growth in the Australian logistics services market is likely to be created from present customers seeking improved level of services (Dapiran *et al.*, 1996, Murphy and Poist, 1998, Sohal *et al.*, 2002, Lieb and Kendrick, 2003). Strategic design Development (2004) supported the idea that there has been a significant change in the Australian market for logistics services over the last twenty years. This has partly been driven by the withdrawal of governments from supplying logistics services and by changes in demand as customers increasingly recognise the importance to their competitive position in logistics and supply chain management (Strategic design Development, 2004). The initiation of strategies by large retailers, such as Woolworths and Coles Myer, to gain control over the primary freight task (from the supplier's factory or warehouse to the retailer's distribution centres) has been one of the biggest change in the demand for logistics service in Australia (Strategic design Development, 2004).

## **2.2 Perishable Food Handling and Quality Assurance (QA)**

A shipment is defined by the International Air Transport Association (IATA) as perishable if its contents deteriorate over a given period of time when exposed to

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excessive temperature or humidity (Fedex, 2005). This section discusses the nature and issues of perishable food handling and quality assurance. Broadly, these encompass:

- Australian aquaculture industry;
- Nature of perishable food handling;
- Cold chain management;
- Food safety and quality assurance standards in handling perishable food;
- Quality; and
- Financial Impact of Quality Assurance.

### **2.2.1 Australian Aquaculture Industry**

The Australian aquaculture industry began in the late 1800s with the successful introduction of trout from the northern hemisphere and the cultivation of the native Sydney rock lobster (AFFA, 2001a). With the beginning of the atlantic salmon industry in Tasmania in the 1980s a new wave of aquaculture began. In addition to this, there was the commercial cultivation of native freshwater finfish, freshwater crayfish, prawns and Pacific oysters. These are sold as live, fresh, chilled, frozen, canned, dried, salted or smoked products. Aquaculture is now established throughout Australia with 95 percent of the gross value of production being four main species – edible oysters, salmon, prawns and tuna (ABARE, 2004b, Invest Australia, 2006). In total, there are over 60 species being produced and the species that are cultured vary widely between regions, according to different climatic conditions.

Most of Australian aquaculture operations are coastal with a small amount of high-value species. To guarantee that farm operations do not have an unacceptable impact on the marine environment, marine farming is licensed (AFFA, 2006). The Australian state and territory government departments are generally responsible for aquaculture development, monitoring and management and collecting aquaculture statistics. These departments have the responsibility for fisheries and aquaculture in both marine and freshwater aquaculture. This is the responsibility of the same department in each state and territory (ABARE, 2004a). However, in Tasmania the Department of Primary Industries, Water and the Environment has



the responsibility of marine aquaculture while the Inland Fisheries Service has the responsibility for freshwater aquaculture.

The value of Australian aquaculture has been estimated and reported in terms of the gross value of production at the farm gate (ASIC, 2003, ABARE, 2004b). Aquaculture is the fastest growing primary industry in Australia, with an increase in value by an average of 13 percent per annum since 1990 (Invest Australia, 2006). The annual value of the aquaculture industry is in excess of \$400 million (CSIRO, 2004). In 2003-2004, Australia produced around 45,822 tonnes of aquaculture products. South Australia is Australia's largest producer in regards to value and volume of production, as well as the amount of aquaculture authorisations granted. These accounts for 38 percent of the gross value of production (PIRSA, 2006). In terms of Australian production this is followed by Western Australia (25 percent), Tasmania (17 percent), Queensland (10 percent), New South Wales (6 percent), Victoria (3 percent) and Northern Territory (1 percent) (Invest Australia, 2006).

The Australian aquaculture industry is aiming to achieve annual sales of \$2.5 billion by 2010 (Invest Australia, 2006). It has been estimated that the industry contributes \$10 billion worth of income activity into the Australian economy annually. Australia's long-standing strengths in shellfish products in the pearling and edible oyster sectors have helped the expansion on the aquaculture industry. In addition to existing products of high-value for the domestic and international markets, there has been a rapid increase in expertise with abalone, marine finfish and crustaceans, and freshwater finfish and crayfish (AFFA, 2001a). In the last decade a number of aquaculture producers have been vertically integrating processing, marketing, retailing and transport into their businesses to add more value to the farmed product and to increase efficiencies in the supply chain from point of harvest to consumer (ASIC, 2003).

### **2.2.2. Nature of Perishable Food Handling**

Banja (2002) noted that in general, food is able to be classified into three main categories: perishable, semi-perishable and non-perishable products. Over the last

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decade there has been an evolution in perishable food industries from horizontal alignment to vertically coordinated value chains, reflecting the needs of supermarkets and food service customers. O'Keefee (2001) identified the two major motivators of the evolution of supply chain participants changes from horizontal to vertical structures as:

1. The demands by consumers for safe food that is able to be traced back to the farm where it comes from; and
2. Retail and food supply company consolidation and consistency requirements.

At every step in the transportation of perishable food there must exist specific standards to guarantee suitable safety levels, creating the need for the whole food chain to be monitored (Wilm, 2005). Small companies through to industries and even the whole economy of a country can be dramatically effected by any breakdown in the integrity of the food supply chain (Whitehead, 1998, Deloitte, 2004). While speed and duration of time for delivery are critical, the reputation of suppliers is guaranteed mainly by the quality of the products at market. Problems exist when there are extended waiting times at shipping or receiving facilities. Often there is a threat to the integrity of heat-sensitive cargo when there is a waiting time associated with temperature controlled carriers (Michael and Goldsby, 2002).

Time and temperature abuse during handling is one of the more common causes of perishable food poisonings around the world. Hence, commercial interests and regulatory authorities are increasing their scrutiny of time and temperature controls. This trend was highlighted by the recent mandate for Hazard Analysis Critical Control Points (HACCP) inspection programs for domestic perishable food processors and foreign processors exporting to overseas (Ropkins and Beck, 2000). Temperature abuse usually takes one of two forms (Australian Academy of Science, 1998):

1. Bacteria thrive when there has been a failure in the cold chain, for example, when refrigeration breaks down in a shop or when a consumer

- leaves a shopping bag containing fresh food in a car for an hour or two; and
- 2. During food cooking and storage. Micro-organisms can grow when food is cooked at unsuitably low temperature and are then stored above 4°C which allow bacterial to thrive.

Many supply chain participants see logistics as a black hole (Autoscan, 2005). That is, while there is visibility when goods are being produced in their factories and stored in their warehouses and distribution centres, once they leave these physical locations, visibility is completely lost. For the produce this can have a number of adverse effects:

- Susceptibility to supply chain theft;
- Revenue losses due to out of stock;
- Increase inventory unnecessarily as no one knows if a delivery is going to arrive as per schedule; and
- Increase in secondary costs, such as recovery and storage of spoilt goods, fault diagnosis, and consequent financial and legal actions.

The worldwide demand for perishable foods presents an opportunity for increased profits for producers and logistic service providers. There has also been real market pressure for organisations to minimise management costs, maximise customer service and market opportunities. This has arisen as the demand for perishable foods has been increasing internationally, with customers demanding better quality and higher protein fresh foods. Many successful companies in these industries have reacted by participating in cold chains and developing close alliances with customers and suppliers (O'Keeffe, 2001). In order to provide suitable protection for consumers and to facilitate trade it is necessary to have an acceptable level of food quality and safety. The implementation and monitoring of quality assurance measures along the entire food chain is essential to achieve these objectives. There have been many food safety incidents that have resulted in increased public awareness of the importance of food safety standards (FAO, 1998). This has added pressures on suppliers, transporters and wholesalers/retailers, to guarantee that perishable food distribution chains meet

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the required microbiological and non-microbiological standards (Sanders, 1999). As the complexity of consumer behaviour becomes greater, so does their desire to have a greater knowledge of the origin (species, conditions of rearing or catching), the distribution and the transformation of their food products (Pascal and Mahe, 2001).

Logistics management of perishable foods presents some of the biggest challenges of any supply chain (Otwell, 2005). To get everyday fresh foods like perishable foods products to the customer's table in the best condition, it is essential to keep the product at a low temperature (Ashby, 1995). Refrigeration technology has become an important tool to reduce microbial and toxins growth (Thompson, 2005). SRCRA (1991) reported that there is a high demand for transportable and energy efficient refrigerated containers for the distribution of perishable food products. The key objective of refrigeration is to prolong the storage life of a perishable product. This is achieved by lowering the temperature in order for metabolic deterioration and decay caused by micro-organisms or enzymes to be retarded.

Logistics providers, who use temperature-controlled transportation (refrigerated transportation) to deliver products to customers should ensure the temperature and humidity is within certain parameters throughout transportation. Currently, this means that time, temperature, humidity and other environment parameters are read and inspected only at distinct, identified points in the distribution chain with little information available on any potentially adverse parameter fluctuations between these readings throughout the entire transportation process (Thompson, 2005).

The Australian Food and Grocery Council (AFGC) (1999) stated that the delivery of safe and high-quality products to consumers requires that businesses are linked in a cold chain that complies with temperature requirements for handling and storage of chilled and frozen foods. According to Harris & Chaney (1969a), how effective a quality system is in satisfying quality objectives mainly depends on the quality of job performance by people. Tuncer (2001) also acknowledged that the quality of food products is dependent upon a number of characteristics that

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determine the quality of performance.

### **2.2.3 Cold Chain Management**

This section will focus on the cold chain management:

- Temperature monitoring equipment; and
- Traceability and recall procedures.

According to Bogatai and Vodopivec (2005) and the Seafood Network Information Center (SeafoodNIC) (2005), cold chain management refers to the process of planning, implementing and controlling efficiency, effective flow and storage of perishable goods. This begins at one or more starting points, through the production and distribution stages to the point of consumption. It integrates existing business activities, including special activities for perishable goods and conserving along value chains, where suppliers of certain raw materials appear to create value for the end user. There is a need for product and environment temperatures to be closely monitored and recorded during the distribution process. Therefore, monitoring a cold chain necessitates detailed information on the temperature and history of food products (Seafood Network Information Center, 2005). However, most companies have been unwilling to share information with other companies, even with business partners (Keen and Thamworrawong, 2006). The use of information systems in traditional supply chain management was examined by Sensitech (2004) and was based on two forms of information:

#### **1. *Transaction Information***

All financial details of the exchange of goods for currency are conveyed by transaction information. Details of how much material was purchased, sold, shipped, as well as the amounts of money paid and received, are provided by order management/CRM, purchasing, shipping, point-of-sale systems.

#### **2. *Location Information***

Location information focuses on the actual location of goods throughout the chain, for example in-transit (traffic) or in the warehouse, using inventory systems. However, cold chain management requires additional information

about the condition of the products such as temperature, humidity and shelf life.

Temperature control throughout the period between harvest and consumption has been found to be the most crucial factor in maintaining the quality of products and is a part of a Total Quality Management (TQM) programme (FAO, 2005). The Seafood Network Information Center stated that temperature abuse of chilled foods is more likely than frozen foods, given the ability of a chilled food's temperature to rise quickly (Seafood Network Information Center, 2005). Chilled foods are more vulnerable to microorganism spoilage as a result of variations in temperatures. This also has the ability to shorten the shelf life of these goods (AFGC, 1999). It is recommended by the Australian Cold Chain Guidelines that, in order to maximise product safety and quality, chilled products must be stored and handled at 0°C to +4°C, and to ensure that the product temperature is never above +5°C. Frozen products must be stored or handled at -18°C or below (AFGC, 1999). A variation of only 1°C can make a difference to growth rates of micro-organisms (Seafood Network Information Center, 2005).

In addition, CSIRO (1995) has advised that the surface temperature of meat products should not exceed 7°C and that the internal temperature should not exceed 5°C. The fluctuations in temperature, heat and humidity levels during transportation can impact directly on food safety, product yield, colour, smell, texture, viscosity, grade, odour, product flavour, size, shape, weight, and taste (Foodproductiondaily, 2004a). Proper harvesting, post-harvest handling, storage and transport of fresh perishable foods all contribute directly to the appearance, flavor, texture, odour and nutritional value of the produce (Gorga & Ronsivalli, 1988). Breaks at any points in the cold chain can result in food that is likely to cause food poisoning and/or irreversible damage to the quality of the product.

Spoilage is a major concern, with typically 10 percent of chilled stock lost to sales during transportation (Seafood Network Information Center, 2005). Increasingly, organisations have become aware of the need to track the location of perishable foods consignments as well as measure and monitor stock temperature and humidity during transit. Excess dryness or humidity can have a detrimental effect

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on many fresh foods (The European Food Information Council, 2003). If perishable foods are stored in conditions of excess dryness it may result in dehydration while excess humidity can lead to the growth of mould, bacteria or fungus. At levels of 85 percent to nearly 100 percent in relative humidity, over prolonged periods significant microbiological spoilage will occur (Holah and Thorpe, 2000). In addition, these authors have suggested that in order to control humidity, one must look at how air is circulated around products in trucks, shipping containers and storage areas. The type of container being used to store the perishable food, and the mode in which the containers have been packed together also can have bearing on the amount of humidity present. To maintain product quality, integrity, suitability and safety, the transportation of perishable foods requires temperature, shelf life and/or environment controls to be monitored closely during the distribution process (SRCRA, 1991, Lovell, 2002, Seafood Network Information Center, 2005).

The safety and quality of perishable foods depends very much on the time and temperature history of the goods. All perishable foods do not have the same requirements. Therefore, perishable food providers have to select the best solution to delivering products to customers in the best possible condition. According to AFGC (1999), the three main issues for cold chain management are those that may result in harm to the consumers:

**1. *Microbiological Hazards***

These are caused by bacteria, fungi, viruses, parasites and the toxins that are produced by those micro-organisms. These are living micro-organisms that have the ability to cause food spoilage and possibly food poisoning for consumers. These can be either directly or indirectly harmful to health.

**2. *Chemical Hazards***

These are associated with the use of chemical additives, processes and controls in the agricultural and food industries. According to Matthews and Ravelo (2005), chemicals may be widely used in the processing and distribution stages of the food supply chain in order to provide or preserve specific product features, for example, prevention of mould growth.

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### 3. *Physical Sources*

Physical hazards within the food or its source, for example, bone chips, hair, leaves, seeds, manure. Physical agents in food include glass, metal, plastic, personal effects and packaging components.

#### **2.2.3.1 Temperature Monitoring Equipment**

The accuracy and implementation of temperature measurement techniques are essential, due to the importance of controlling temperature to guarantee a safe and quality product (AFGC, 1999). Rooney (1998) defined perishable foods as being those that require conditions of reduced temperature to prevent rapid quality loss through microbiological, physiological or chemical spoilage. It has been acknowledged that one part of the incorporated safety and quality is temperature measurement and new technology aids in the storage and processing of the data (Woolfe, 2000). The AFGC, Australian Supermarket Institute (ASI), and Refrigerated Warehouse and Transport Association of Australia (RWTA), 1999) stated that temperature control is so important in the protection of product safety and quality. It is crucial that temperature measurement techniques are accurate and correctly implemented. The Seafood Network Information Center (2005) proposed the time-temperature tolerance (TTT) approach. The approach refers to the relationship between storage temperature and storage life and can be used to predict the effects of changing or fluctuating temperature on shelf life quality.

Within a cold chain there are five measurement devices which are available commercially (AFGC, 1999, Woolfe, 2000):

##### 1. *Digital Thermometers*

A digital thermometer equipped with either a flat blade or needle probe is usually the most efficient temperature measuring device.

##### 2. *Bi-metal Thermometers*

A bi-metal dial thermometer is installed at the point of measurement and is usually read from that location. The accuracy of a bi-metal thermometer is shown as a percentage of the maximum scale range.



### **3. *Glass Thermometers***

Glass may be dangerous, which is an issue when using mercury-in-glass or alcohol-in-glass thermometers. They are unsuitable for contact with products, however, they may be used for some applications, such as when mounted on a wall in a cold store rooms where there is minimal risk of a product being contaminated by the glass.

### **4. *Infra-red (non-contact) Thermometers***

These thermometers swiftly and accurately measure product surface temperatures and can be purchased with calibration equipment. It is important to follow the manufacturer's instructions and hints using these thermometers on shiny and/or reflective surfaces or when a significant amount of air space exists between the product and its packaging.

### **5. *Temperature Data Loggers***

Data loggers are among the systems available that can be used to monitor the effectiveness of the cold chain beyond the packing shed to the final destination.

## **2.2.3.2 Traceability and Recall Procedures**

The ability to trace products, ingredients, suppliers, retailers, processing operations or modes of storage through the food chain is an important part of quality and safety assurance, and this is particularly significant when there are occurrences of failure (Frederiksen and Gram, 2003). The term "traceability" describes operations in which information on the attribute of a certain food product is recorded methodically from conception through to when it is marketed (Golan *et al.*, 2002). This includes specifications of ingredients, records of storage and what processes were undertaken to meet safety, quality and legal requirements (Food Standard Agency, 2004). Doyle (2004a) stated that in reassuring consumers and traders that food meets safety standards, traceability is an essential tool – a potential risk management tool for public health purposes. According to Sarig (2003), traceability capability is needed to guarantee that all the chain process effects are able to be addressed and measured. Mitic (2005) lists

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the three key elements of traceability that should be considered by supply chain participants as:

1. Accuracy;
2. Speed of data recording; and
3. Cost effectiveness.

There has been an increase in interest of traceability in food processing, partly as a result of the various food related crises such as mad cow disease (Bovine Spongiform Encephalopathy (BSE) in 1996 in the UK and the dioxin contamination in Belgium in 1999 (Golan *et al.*, 2002, Frederiksen and Gram, 2003, United States Senate, 2003, Becker, 2004, 2005). The Food Recall Statistics from FSANZ reported that between 1 January 1990 and 31 December 2003, 598 recalls of food were notified to FSANZ in this period, with 205 (34 percent) due to microbial contamination, 89 (43 percent) due to *Listeria monocytogenes* contamination, 42 (20 percent) due to *Salmonella* contamination and 26 (13 percent) due to *Escherichia coli* contamination (FSANZ, 2004a).

Foodproductiondaily (2005) stated that in order to make food manufacturers responsible for the safety of the food they produce and distribute, a systematic registration of information, to include name, address of producer, the nature of products and date of transaction must be made. This must be kept for a period of five years, and be immediately available upon request to competent authorities. The guideline places the responsibility for the safety of the food they produce and distribute, on the manufacturers. As noted by Borresen (2003) and Thompson *et al.*, (2005), the perishable food industry is a commercial sector in which traceability is becoming a legal and commercial necessity. As pointed out by Bledsoe & Rasco (2002) and Thomson *et al.*, (2005), traceability will make an impact on the perishable foods industry, driven largely by growing food safety issues such as bio-terrorism, the outbreak of food poisoning and the demand by consumers for detailed information on the nature, origin and quality of the food they are purchasing. Foodproductiondaily (2005) recommended that new mandatory traceability requirements apply to all food, animal feed, food-producing animals and all types of food chain operators from the farming sector to

processing, transport, storage, distribution and retail to the consumer. Regulation 178/2002/EC in the General Food Law stated that all food and food businesses within the EU are required to implement basic traceability systems in all stages of the food chain. The use of automated data collection is practically needed in order to do so in a timely and cost effective manner (Zebra Technologies, 2005).

Traceability can relate to:

- The origin of components and materials;
- The history of the processing; and
- Post delivery distribution and location of the product (ISO, 2000).

According to the EC Regulation 178/2002, the three main roles of traceability systems in food businesses are (Food Standard Agency, 2004):

1. To help to meet the regulatory demands and customer desire for information, and to help in process control and management (efficient use of materials, stock and quality control);
2. To identify causes of problems and to prevent problems from recurring. They are important to help the withdrawal or recalling of faulty products; and
3. Enable producers to authenticate marketing claims that are unable to be supported by analysis.

There is an increased need for product chain information throughout the chain as a result of the broad recognition of HACCP systems for safety management (McKean, 2001). There is also a need for traceable information to be reliable and this is made even more essential because of the open access of other chain members enabling them to audit the quality assurance systems in the chain. Chain traceability is the key to collaboration and common trust between independent companies in a chain (Frederiksen and Gram, 2003). A study by Frederiksen and Gram (2003) presented two types of the traceability in food processing as:

1. Internal traceability; and
2. External (chain) traceability.

- ***Internal Traceability***

Internal traceability refers to a company or location which is under consideration. Data concerning raw materials and processes within the business is able to be linked to the final product separately in all stages of production, processing or distribution as a result of internal traceability (Food Standards Agency, 2002).

- ***External (Chain) Traceability***

Answer4business (2005) stated that external traceability refers to the data exchange and business processes that take place between trading partners. The focus is on the maintenance of product information from one link in the chain to another, describing which data are transmitted and received, and how (Food Standards Agency, 2002).

Golan *et al.*, (2004) presented three broad views of the benefits of traceability in a food distribution chain. The benefits of traceability can be broadly categorised as:

1. ***To Improve Supply Chain Management***

Despite the high costs associated with the implementation of traceability systems, the producer can reap economic benefits as a result of their being adopted, with the entire chain being able to be managed in more effectively when the traceable information is utilised actively in an effort to augment mutual trust and co-operation between each step in the chain. There can be a significant saving of time and money re quality checks and storage, and when there is a need for recalls to be effected, traceability enables the company to limit the loss and affords a protection of its brand on the market. (Frederiksen, 2002).

2. ***To Facilitate Trace Back for Safety and Quality Control***

Traceability systems help supply chain participants isolate the source and extent of safety or quality control (QC) problems. This helps reduce the

production and distribution of unsafe or poor-quality products, which in turn reduces the potential for bad publicity, liability, and recalls.

**3. *To Differentiate and Market Foods with Subtle or Undetectable Quality Attributes***

This implies the ability to discern between content attributes that are difficult for consumers to determine such as different between a genetically product and a conventional product.

**2.2.4 Food Safety and Quality Assurance Standards in Handling Perishable Food**

This section will focus on the food safety and quality assurance standards in handling perishable food. After a brief introduction it will specially focus on:

- Food safety standards in Australia; and
- QA standards in perishable food handling.

The desired effect of food safety assurance is the elimination of risks to humans that may occur in food. The totality of features and characteristics of a product that bear on its ability to satisfy stated or implied needs is how the International Standards Organisation (ISO) defines quality, a term defined by consumers, buyers, graders or any other clients based on a number of subjective and objective measurements of the food product. These can include gauges of nutrition, purity, flavor, maturity or any other characteristics of the product (University of Maryland, 2002). SeafoodNIC (2005:7-8) viewed that “safe and high quality chilled foods require minimal contamination during manufacture (including cross-contamination), rapid chilling and low temperatures during storage, handling, distribution, retail display and consumer storage” . WHO (2003c) stated that food safety is an issue that demands to be addressed along the entire food chain by measures that are based on sound scientific information at both national and international levels. They recommended that the following approaches should be used all along the farm-to-fork continuum in an effort to minimise the burden that unsafe food places on national and international communities (WHO, 2003c, b). In so doing it requires:

- Surveillance of food borne diseases;
- Better risk assessment;
- Safety of new technologies;
- Public health in codes;
- Risk communication;
- International co-operation; and
- Capacity building.

#### **2.2.4.1 Food Safety Standards in Australia**

This section will discuss the food safety standards that are effecting the food supply chain requirements in Australia. These were first contemplated in the passing more stringent food safety legislation in the 1970s. There was a growing trend within the Australian food industry in the 1990's toward Quality Assurance. The Australian Quarantine and Inspection Service (AQIS) has been the main driver to promote Quality Assurance (Fabiansson and Cunningham, 2000). Woolworths developed the Woolworths Vendor Quality Management Standard (WVQMS) in 1996 (Food Regulation Standing Committee, 2006). This standard identifies the minimum controls a supplier needs to have over the purchasing, production, storage, packaging and distribution processes (Fabiansson and Cunningham, 2000).

The Australian Government is committed to a comprehensive food policy that aims to optimise food safety and quality throughout the food supply chain (Truss, 1999). It seeks to ensure the safety of all food produced and consumed in Australia, as well as what is exported, is of appropriate quality, safe and conforms to the standards (Fabiansson and Cunningham, 2000, ANZFA, 2001a). The concern for food safety has been responded to by the Australian Government with tougher legislation, industry guidance, food safety initiatives, and investment in research and education programmes. AQIS, Australia New Zealand Food Authority (ANZFA), and Australia New Zealand Food Standards Council (ANZFSC) are pushing these initiatives. It is a requirement of State and Territory food laws that perishable food prepared and sold by food industries is safe to eat (ANZFA, 2002). According to ANZFA (2001a) the shortcomings of the existing

food-hygiene regulatory system were identified in 1995, and led to the then ANZFA, now called Food Standards Australia New Zealand (FSANZ), developing uniform food safety standards for Australia and New Zealand.

The food standard code was planned to guarantee that safety measures are applied at all stages of the food supply chain, from primary producers through to retailers. At this time, all food producers, including those in the aquaculture sector, were obliged to make and sell “safe” food under the Food Standards Code and State and Territory Food and/or Health Acts. The food safety standards have been developed to provide the means to guarantee that this legal obligation is met. In order to ensure food integrity there is a need to satisfy regulatory and customer demands for food safety, quality as well as other emerging requirements. These include assurances on environmental management, animal welfare and complete traceability. This section will highlight several quality assurance standards as applicable to aquaculture, shellfish and confectionary in Australia and listed in Table 2-3 below:

**Table 2-3. A Summary of the Quality Assurance Involved in this Study**

Standard	Application
<b>1. Australian Standard for the Hygienic Production and Transportation of Meat Products for Human Consumption (CSIRO, 2002)</b>	Production and transportation of meat and meat products within Australia
<b>2. Australian Standard for Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption (CSIRO, 2005)</b>	Part A of this standard applies to the construction and equipment of all processing premises where poultry are slaughtered for the production of poultry meat for human consumption, while Part B of this standard applies to the hygienic production for human consumption of products derived from poultry
<b>3. Primary Production and Processing Standard for Seafood (FSANZ, 2006b)</b>	Food safety for seafood from farmer to consumers
<b>4. Food Safety Standard 3.2.1 (ANZFA, 2001a, b)</b>	Apply to businesses/sectors involved in operations identified as high risk
<b>5. Standard 2.5.6 Ice Cream (FSANZ, 2006a)</b>	Apply to ice cream industry
<b>6. Cold Chain Guideline (AFGC, 1999)</b>	Prepare for Australian cold chain in order to maintain cold chain requirements and ensure the safety and quality of chilled and frozen foods
<b>7. The Australian Shellfish Quality Assurance Program (ASQAP): Export Standards (DAFF, 2004)</b>	Criteria for determining the export of shellfish for overseas markets
<b>8. Standard 4.2.1 Primary Production and Processing Standard for Seafood (ANZFA, 2005, FSANZ, 2006b)</b>	Apply for food safety and suitability requirements for seafood generally from farm up to but exclude manufacturing activities
<b>9. Woolworths Quality Assurance (WQA) (Bennett, 2005:2-3)</b>	WQA is mandatory for all Woolworths direct suppliers of fresh food and indirect suppliers who pack Woolworths-branded produce. It focuses on the product quality and safety of individual products. Although the WQA Standard is available from Woolworths, vendors participate in the program by invitation only

#### 2.2.4.2 QA Standards in Perishable Food Handling

Below are listed the most well known methods to manage quality and/or safety (Huss and Ryder, 2004a):

- Risk Analysis;
- Good Agricultural Practices (GAP), Good Hygienic Practice (GHP) and Good Manufacturing Practices (GMP);
- Sanitation Standard Operation Procedures (SSOP), Standard Operating Procedures (SOP);
- HACCP;
- CODEX;



- ISO 9002, ISO 22000;
- Safe Quality Food (SQF) 1000, 2000; and
- Meat Safety Quality Assurance (MSQA).

• ***Risk Analysis***

A risk-based approach aims to diminish human exposure to food borne pathogens by recommending that regulators closely examine the critical control points in the production process. These are points where food safety hazards can be prevented, reduced to a level that is acceptable, or eliminated altogether (WHO, 2003c, b). Food safety management approaches such as the increased employment of risk analysis are a response to the increasing global need for food safety. Historically, the majority of the factors that contribute to the global emergence of food safety as a significant issue include:

- Growing problem of food borne illnesses and food borne hazards;
- Technologies in food production, processing and marketing which are changing quickly;
- Developing science-based food control systems which concentrate on consumer protection;
- International food trade and the necessity that food safety and quality standards work in harmony;
- Changing lifestyles including swift urbanisation; and,
- Awareness by the consumers which is growing re food safety and quality issues as well as growing demand for greater information (WHO, 2003a).

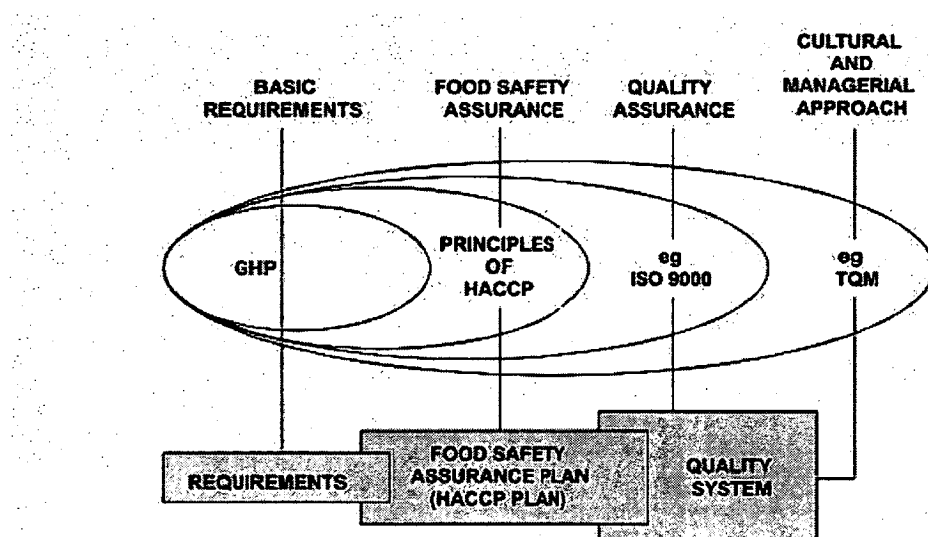
The overall aim of risk analysis is to reduce risk by:

- The identification of realistic microbiological hazards and sorting them according to their severity;
- The close observation of the impact of raw contamination, processing and use on the level of risk; and
- The clear and consistent passing on of information re the level of risk to the consumer by the output of the study (Brown, 2000).

- **GAP, GHP and GMP**

According to FAO (1998), the key to providing a sound safety assurance program are Good Agricultural Practices (GAPs) and Good Manufacturing Practices (GMPs). University of Maryland (2002) acknowledged that GAPs and GMPs are guidelines created to guarantee a working environment that is clean and safe for all employees while eliminating any potential for contamination of the food products. Huss and Ryder (2004a) viewed the GMP or Good Hygienic Practice (GHP) is acknowledged as the minimum requirements in the food processing industry. For many years they have been in existence and are an essential means of traditional food control. In modern food control systems these concepts are still crucial and provide the basic environmental and operating conditions for production of safe food and are a basis for HACCP in an overall food safety management programme. However, Jouve (1998) suggested that for clarity of scope and practice of food safety legislation, the application of good practice and the development of HACCP based safety assurance plans should be separated.

Figure 2-4 provides a graphical summary of the appropriate methods and tools for food safety and quality. It shows that GHP and the principles of HACCP are appropriate methods, while ISO 9000 and TQM provide the tools.



**Figure 2-4. Food Safety and Quality, an Integrated Approach**

Source: (Huss and Ryder, 2004b:1)

- **SSOP, SOP**

According to the University of Maryland (2002), Sanitation Standard Operation Procedures (SSOP) is the recommended procedure that should be followed for cleaning and sanitation activities to be performed correctly. SOPs detail the work processes that are to be conducted or followed and documents the way activities are performed for consistent conformance to safety and quality system requirements facilitation. SSOP is a key component of a safety plan and includes the development of detailed descriptions of cleaning procedures and sanitation operations requirements to prevent contamination or degradation of the product (USDA, 1999). SSOPs also identify the employee(s) responsible for the implementation and maintenance of each procedure.

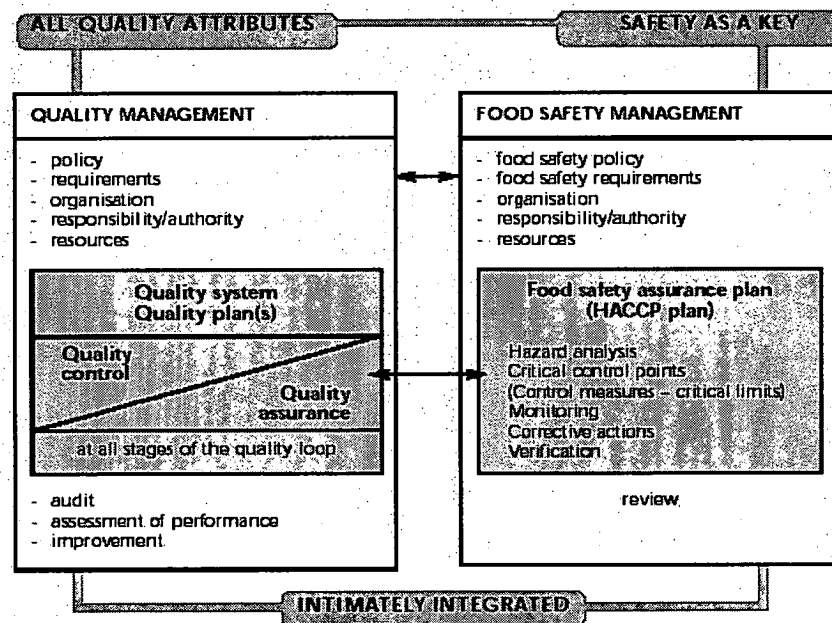
- **HACCP**

HACCP is an internationally recognised and recommended inspection process as well as standard for food safety that anticipates and prevents hazards associated with ingredients (Alli, 2004). HACCP was developed in reaction to various outbreaks of food contamination. It could be viewed as a self-inspection management system that addresses food safety through the analysis and control of biological, chemical and physical hazards (Huss and Ryder, 2004b). The HACCP system evolved from the hazard analysis and critical control point (CCP) system of the 1960's, which was developed in the USA and used in the NASA space program (Ropkins and Beck, 2000). Endorsed by the FDA and other US agencies and developed further by the International Commission on Microbiological Specification, the guidelines for its application were defined in 1990 by the Codex Alimentarius Commission. The guidelines have evolved over the years.

Basically the principles require an organisation to map their processes and look for things that could go wrong (hazards) from a food safety perspective (Brown, 2000). The organisation then needs to identify ways to prevent the hazards from occurring through monitoring of processes and implementation of other support programs. The organisation then needs to create procedures and forms to support the program (Doyle *et al.*, 1997, Jouve, 1998, Fabiansson and Cunningham, 2000). HACCP can be applied from raw material production, procurement and

handling, to manufacturing, distribution and consumption of the finished product, ie throughout the entire food supply chain (Jouve, 1998, Sanders, 1999, Geno, 2001). Since HACCP is a tool and a methodology, it is not a quality system per se, but a system implemented to ensure food safety and to avoid food borne health risks (ANZFA, 1999). It is directly compatible with the quality assurance systems and is usually implemented in food processing companies together with QA systems (Heap, 2000, Woolfe, 2000). It should be viewed clearly as a food *safety* system that is used together with a food *quality* system (eg ISO 9000) and that it does not address many of the quality aspects of food regulations.

This integration of HACCP and quality system is shown in Figure 2-5. This illustrates the link between the issues relate to food safety management and quality management.



**Figure 2-5. Food Safety and Quality Management**

Source: (Jouve *et al.*, 1998:13)

The HACCP safety system is used by many authorities and is the most popular and internationally accepted food safety system (Alli, 2004). The seven principles of HACCP are (Sanders, 1999, Luning *et al.*, 2002):

1. Conduct a hazard analysis. Prepare a list of steps in the process where significant hazards can occur and describe the preventive measures;
2. Identify the Critical Control Points (CCPs) in the process;
3. Establish critical limits for preventive measures associated with each identified CCP;
4. Establish CCP monitoring requirements. Establish procedures for using the results of monitoring to adjust the process and maintain control;
5. Establish corrective actions to be taken when monitoring indicates that there is a deviation from an established critical limit;
6. Establish effective record-keeping procedures that document the HACCP system; and
7. Establish procedures for verification that the HACCP system is working correctly.

• **CODEX**

The Codex Alimentarius (means 'food code' in Latin) Commission (CAC) is an intergovernmental body created in 1963 and jointly sponsored by the Food and Agriculture Organisation (FAO) and the World Health Organisation (WHO) to develop food standards, guidelines and codes of practice under the Joint FAO/WHO Food Standards Programme (CAC 1993). The main purposes of this programme are to protect the health of the consumers and ensuring fair trade practices in the food trade, as well as promoting coordination of all food standards work undertaken by international governmental and non-governmental organisations. Like ISO 9000 and ISO 22000, Codex develops standards, especially minimum standards for developing countries, which can be applied to food (FAO, 1998, ANZFA, 2001b). The organisation also sets minimum dietary and nutrition standards and looks at related areas such as vitamin and mineral supplements (ANZFA, 1999).

• **ISO 9002, ISO 22000**

In 1946, the ISO was founded to promote the development of international standards and to facilitate the exchange of goods and services to develop the

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cooperation in the spheres of scientific, technological and economic activity throughout the world (Gould and Gould, 2001, Mazzei, 2005). The first ISO family standards were published in 1987 and was then updated in 1994 and 2000 respectively (Gould and Gould, 2001, Quazi *et al.*, 2002). The ISO 9000 series of standards is a widely used ISO standard for Quality Management Systems (Noonan and McAlpine, 2005). Two standards, ISO 9000 and ISO 14000 are known as generic management system standards (Huss and Ryder, 2004b).

The main difference between the three standards concerns the scope of the standards (Paradis and Small, 1996, Gould and Gould, 2001, Luning *et al.*, 2002, Huss and Ryder, 2004b):

- ISO 9000 was the guideline for selection and use of the standards on quality management, quality system elements, and quality assurance;
- ISO 9001 was the standard for quality assurance for companies involved in the process design/development, production, installation and servicing. It the most comprehensive standard and contains twenty elements (Surak and Simpson, 1994);
- ISO 9002 was the standard for quality assurance in the processes production, installation and servicing. It contains nineteen elements of the twenty;
- ISO 9003 was the standard for quality assurance in the processes final inspection and test. It provides the least comprehensive quality management system and contains sixteen elements of the twenty; and
- ISO 9004 was the guidelines for quality management and quality system elements. Guidelines provide guidance for a supplier to use in developing and implementing a quality system and in determining the extent to which each quality system element is applicable.

The ISO 22000 standard was released in 2005 and is an international standard designed to ensure safe food supply chains. Frost (2003:28) stated that “ISO 22000 specifies the requirements for a food safety management system in the food chain where an organisation needs to demonstrate its ability to control food safety hazards in order to provide consistently safe end products that meet both the

requirements agreed with the customer and those of applicable food safety regulations". Traceability in the feed and food chain is a part of ISO 22005. A further major benefit of the new standard is that makes it easier for organisations throughout the world to implement the Codex HACCP system for food hygiene in a coordinated way (Faergemand and Jespersen, 2004). There are three main elements to the ISO 22000 standard:

- Requirements for good practice;
- Requirements for HACCP; and
- Requirements for a management system.

ISO 15161:2001 combines ISO 9001:2000 and HACCP. It is a useful model for the improvement of business in the food industry. The standard deals with all aspects of food quality and illustrates how a HACCP system can be integrated into a quality management system.

• ***SQF 1000, 2000***

In response to primary producers and food processors changing needs, the Safe Quality Food (SQF) programs have continued to evolve since 1995 (Noonan and McAlpine, 2005). This is in response to customers demand for consistent quality and safe food. Therefore SQF focuses on customer requirements within an evolving structure and implementation program that meets both the requirements of the customer as well as the business. This can be applied to all the needs of all sectors of the supply chain.

In 1997, the SQF 1000 was developed to ensure its applicability to the primary production sector. The SQF 1000 Code focuses on the benefits to both industry and the customer, whereby assured safety and improved product quality enhances marketability and profitability. The SQF 1000 process necessitates both the manufacturers and the customers to agree to the specification of the product to be supplied. The SQF 2000 is a program which originated in Australia. It has been designed specifically for the food sector, and is a fully integrated food safety and quality management protocol. The compliance of a product, process or service

with international standards is validated by SQF Certification. This gives assurance to a food supplier that the production, handling and preparation of foods are performed according to the highest possible standards. SQF 1000 is for growers and SQF 2000 is for packers and food manufacturers.

• **MSQA**

The Meat Safety Quality Assurance (MSQA) approach was taken by Australian Quarantine and Inspection Service (AQIS) to provide Australian export meat organisations with an integrated system which, when applied, will assist in the production of safe meat and meat products for human consumption (Meat Inspection Division, 2005). An advantage of MSQA is that it is consistent with ISO 9002:1994 and utilises the Codex Alimentarius Commission HACCP methodology to address process control. To ensure sustained process control, MSQA integrates HACCP, standard operating procedures (SOPs) and work instructions (WIs).

Table 2-4 shows the international quality assurance standards relevant to food safety.



**Table 2-4. Summary of the International Quality Assurance Standard**

Sector	Standard or Organisation	Relevance	Comments
	HACCP	Safety only	Food safety assessment
FAO	Codex	Safety (HACCP) & Quality (ISO 9000)	Incorporates HACCP & ISO 9000/22000. Possibly the most widely accepted standard that covers both quality and safety
	ISO 9000	Quality only	Quality assurance & quality management systems
	ISO 22000	Quality (HACCP) and safety	Extension of ISO 9000 covering food supply chains
European Union	EurepGAP	Good Agricultural Practices (GAP)	Food safety, environmental, OH&S, Product traceability
US	SQF 1000	Safety (generic HACCP) & Quality (some aspects of ISO 9000)	US focussed but accepted by European & other countries Possibly the next best option to Codex
	SQF 2000	Safety (customised HACCP) & Quality (some aspects of ISO 9000)	US focussed
Germany	IFS	Safety and reporting	Food safety assessment, traceability
UK	BRC Global Food Standard	Safety & Quality	Supplier assessment program, traceability

### 2.2.5 Quality

The meaning of quality has been given by quality experts or guru's such as Harris and Chaney (1969a), Crosby (1979), Ishikawa (1986), Juran (1990), Deming (1993), Luning *et al.*, (2002), Sixsigma (2005). Harris and Chaney (1969b), Adam and Swamidass (1989), Harrigan and Park (1991), Sohal *et al.*, (1992), Luning *et al.*, (2002), Sixsigma (2005) acknowledged that it is difficult to define the meaning of quality as one particular statement. Sixsigma (2005) stated that quality is meaningful only under certain specified conditions in the product cycle. Novack (1989a:108) proposed the meaning of quality as "quality is achieved when a customer's expectations are met, in other words, quality is achieved when the customer is satisfied". Sixsigma (2003) viewed that quality is something that needs continuous and dynamic adaptation of products and services to satisfy or exceed the needs or expectations of all parties in the organisation and the community as a whole.

Effective quality assurance systems can benefit food industries (Kow, 2005):

- Reduce product loss and increased profit due to improved process management;
- Reduce wastage due to better production management;
- Consistent supply of product to specification;
- Increase customer satisfaction;
- Improve brand image and competitive advantage;
- Improve food safety and quality assurance;
- Develop strengthening of customer relationships; and
- Reduce food recalls.

Gould and Gould (1993:4) suggested that “failures in food quality systems came from the following faults:

- Poor supervision;
- Lack of instructions;
- Varying quality of incoming materials;
- Machines out of control;
- Uncomfortable working conditions;
- Lack of statistical information or performance data; and
- Poor design or processes”.

Rose (2000) proposed differences between quality control and quality assurance. He sees quality control as a reactive activity and quality assurance as a proactive one. Gorga & Ronsivalli (1988: 87) asserted that “quality assurance and quality control have substantially different definitions, noting that while many manuals have been devoted to the subject of quality control, there has been little discussion on quality assurance, apart from within integrated industries”. This has led to some authors declaring the two to be synonymous. Gorga and Ronsivalli (1988) go on to define quality control as being a set of measures adopted within individual companies, while quality assurance is a set of measures that are taken across an entire industry. Quality control can be viewed as the activities devoted to the minimisation of deterioration of quality when a product is within the

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premises of an individual firm, while quality assurance is the maintenance of the expected quality level, which is the responsibility of the industry as a whole.

### **2.2.6 Financial Impact of Quality Assurance**

Bowersox and Closs (1996), Walters (1996), Anupindi *et al.*, (1999), Hines *et al.*, (2000), Frazelle (2001) stated that quality measures and performance measures have been gathered into strategic performance measurement systems.

Cost of quality:

1. Internal failure costs;
2. External failure costs;
3. Appraisal costs; and
4. Prevention costs.

#### **• Internal Failure Costs**

Internal failure costs are the total costs that are incurred as a result of defects detected within the channel of distribution, from the vendors of raw materials to the point of final sale to consumers. The moment the defective product is passed on to the end-use consumer, it becomes an external failure. Internal failure costs include scrap, rework, retest, downtime, yield losses and disposition.

#### **• External Failure Costs**

External failure costs are those that are incurred whenever defective items reach the consumer, and these include complaint adjustment, returned material, warranty charges, allowances, and lost sales. External failure costs per defect are usually both higher and harder to determine than internal failure costs. The biggest variance between internal and external failure costs is that external failure costs contain the cost of lost sales.

#### **• Appraisal Costs or Evaluation Costs**

Appraisal costs are those that include all the expenditures that are needed to determine the quality of material at any stage in the channel of distribution. Examples of these are maintenance of testing equipment, direct labour for

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inspection, and material consumed by testing. Prevention cost is possible in appraisal costs.

- ***Prevention Costs***

Prevention costs are those incurred for activities such as: quality planning, training the workforce, data analysis, implementing improvement programmes. Appraisal costs are incurred when seeking out defects after they occur and failure costs are incurred by dealing with defects after they are detected, prevention costs arise from attempts to prevent defects from happening in the first place.

## **2.3 Technological Developments**

Ahmed (1998) viewed that technology provides various benefits in terms of contributing to the company's effectiveness, improving quality and quantity of products, customer satisfaction as well as brand image. The innovation and diffusion of IS is believed to have had a major impact on patterns of innovation and productivity across a wide range of industries (Surry and Farquhar, 1997, Allen, 2000). However, the introduction of new technologies also means substantial investment in resources such as time, capital, human efforts and organisational energy (Lippert and Davis, 2006).

The relationship between technology and organisation has been an important area in IS research, with an increased focus on understanding the nature and role of technology in organisations (Orlikowski, 1992, 1993b, a, DeSanctis and Poole, 1994, Allen, 2000, Avgerou, 2001). The relationship between technology and the organisation are interdependent and negotiated over time (Rogers, 1995, Avgerou, 2000, Van de Ven and Poole, 2000). Orlikowski (1993b) suggested the successful way to implement technology in organisations depends on how users think about the value of the technology and how they choose to use the technology. Moore and Benbasat (1991) and Allen (2000) argued that IS researchers should be aware of the limitation of the theory of technological innovation as the definition of this theory is broad and lacks an understanding of management, sociology, economics and communication perspectives.

Senior management is viewed as the principal sources of being responsible for the creation and communication of a vision of the change initiative and the program of implementation in order to help achieve this innovation (Fuller and Swanson, 1992, Ahmed, 1998). According to Benjamin and Levinson (1993), senior management should know how to integrate the technology, business processes and organisations in order to develop a comprehensive framework for understanding innovative change in organisations. Oliver (1997) and Markus (2000) argued that organisational practices are influenced by the culture, habit and structure of the organisation which is not easily changed. DeSanctis and Poole (1994:121) also stated that “developers and users of these systems hold high hopes for their potential to change organisations for the better, but actual changes often do not occur, or occur inconsistently”.

Four particular aspects of technological developments will be considered: These are:

- Theories on organisational change;
- Evolution of the concept of innovation;
- Innovation decision process; and
- Technology acceptance models.

### **2.3.1 Theories on Organisational Change**

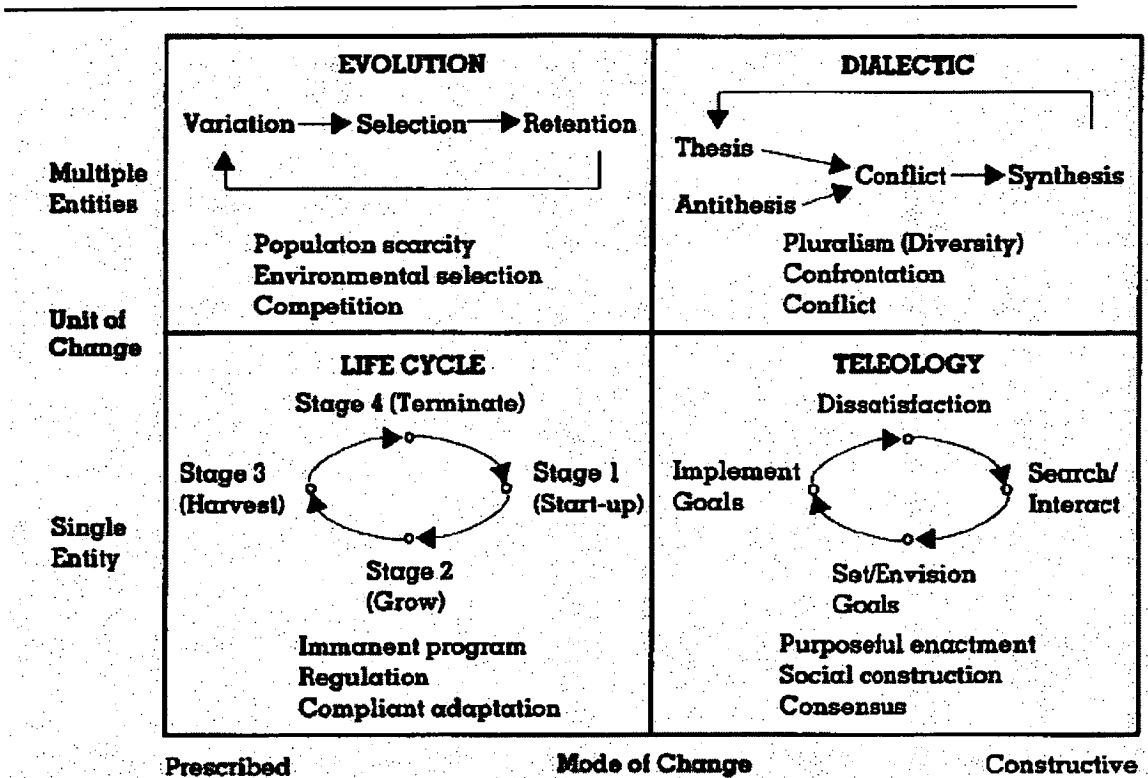
The objective of this section is to expand an understanding of the role of knowledge in the process of diffusion of innovation, and through that develop a conceptual model of the innovative change process in organisations. To study organisational change and development, the researcher explored the theory of Van de Ven and Poole (1995). According to Van de Ven and Poole (1995), there are four types of theories that can explain organisational change. These are:

1. Life-cycle models describe prescribed change in a single-entity view of change and regard change processes as characterised and driven by immanent program, regulation or compliant adaptation. The model describes a process as progressing through a necessary sequence of stages or phases which are cumulative and related;

2. Teleological models explain practical change in a single unit of analysis. This model views development as a cycle of goal formulation and occurring through process step like implementation, evaluation and modification. Development is a repetitive sequence, but not predetermined;
3. Dialectical models clarify change as a trade-off in the balance between opposing entities within or without the organisation. Therefore, disagreement and contradictory values describe the process, and the outcome becomes a result of power struggles; and
4. Evolutionary models explain change as a “recurrent, cumulative and probabilistic progression of variation, selection and retention of organisational entities” (Ven and Poole, 1995: 518). Thus this evolutionary cycle is generated by competition for limited environmental resources between entities inhabiting a population.

Each of these types are fundamentally different but could be use to describe why events occur in particular sequences. Van de Ven (1992) further explained that each of these types represents justifiable traditions and some internal reliability, but varies in terms of types/motors of change (event sequences and generative mechanisms), unit of change, and mode of change.

Figure 2-6 provides a metatheoretical scheme for illustrating and distinguishing the four types of process theories and planned change.



**Figure 2-6. Process Theories and Organisational Development and Change**

Source (Ven and Poole, 1995:520)

### 2.3.2 Evolution of the Concept of Innovation

There are many definitions of innovation (Gatignon *et al.*, 2002). Each of them has their own nuance (Cumming, 1998). The term “innovation” derives from a Latin word “innovare”, which means to change, to alert and to renew (a thing) into something new (Callaghan, 2007). Early definition of innovation has been defined as “a series of technical, industrial and commercial steps” (Robertson, 1974:332). Followed (1969) by the definition of innovation as a unit of technological change by using new methods or inputs in producing goods and services (Marquis, 1969). Another similar view from Badaway (1988) suggested innovation as the generation of a new idea, and its implementation into a new product, process and service. In 1990 Udwadia defined innovation as “the successful creation, development and introduction of new products, process or services” (Udwadia, 1990:66). In 1995, Rogers defined innovation as “an idea, practice, or object that is perceived as new by an individual or other unit of adoption” (Rogers, 1995:11). Gatignon *et al.*, (2002:1107) stated that innovations can be divided into two types. Incremental innovations are “those that improve

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price/performance advance at a rate consistent with the existing technical trajectory” while radical innovations “advance the price/performance frontier by much more than the existing rate of progress”. It is evident that the concept of innovation has changed over the years. From the 1960s and 1970s, innovation was thought of as a process in the induction of change and the generation of new ideas. From 1980s and 1990s, the concept of innovation included conditions such as success, effectiveness, profitability, satisfied customers and business competitiveness (Cumming, 1998).

### **2.3.3 Innovation Decision Process**

In this section the following aspects of innovation decision process will be examined:

- Four main elements in the diffusion of innovations;
- Five steps in the innovation decision process; and
- Barriers to technology adoption and diffusion.

#### ***1. Four Main Elements in the Diffusion of Innovations***

According to Rogers (1995), the diffusion of innovations is a process transmitted over a period of time. He also proposed four elements of the diffusion of innovation process. These are:

1. An innovation is a new idea, practice, or object that is perceived as new by individuals or organisations;
2. A Communication channel is the means of transferring message from one individual to another in order to reach a mutual understanding at all stages of adoption decision process;
3. Time is involved in a process of technology diffusion in many respects. Diffusing innovative knowledge takes time for an individual or organisation to understand in order to adapt or reject, to implementation and use of the new idea and to confirmation of this decision. The classification of an adopter based on a level of innovativeness involved innovators, early adopters, early majority, late majority and laggards; and



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4. A social system is a set of interrelated units (such as individuals, informal groups, organisations, and/or subsystems) that are engaged in joint problem solving to accomplish a common goal.

## **2. *Five Steps in the Innovation Decision Process***

According to Rogers (1995), there are five stages in the diffusion of innovation process. These are:

1. Knowledge stage happens when an adoption unit become aware the existence of an innovation of a product/service and accordingly seeks more sources of how it functions;
2. Persuasion stage happens when an adoption unit sets a favourable or unfavourable attitude towards the innovation;
3. Decision stage happens when an adoption unit engages in some activities which lead to a selection of adoption or rejection of the innovation;
4. Implementation stage happens when an adoption unit accepts that innovation. In this step re-invention may continue over a period of time depending on the nature of innovation; and
5. Confirmation stage happens an adoption unit confirms the decision to adopt the innovation after an innovation decision had been made. This effort might lead to discontinuance (the decision to reject an innovation), if the unit is exposed to the conflicting messages about the innovation (Rogers, 2003).

## **3. *Barriers to Technology Adoption and Diffusion***

This section attempts to review factors that are possibly influential in determining the technology adoption. There are five issues that are taken into consideration based on the research from (Tornatzky and Klein, 1982, Manross and Rice, 1986, Gerwin, 1988, Geisler, 1992, Desai *et al.*, 1998, Intrapairot, 2000) as:

1. Costs of technologies;
  2. Rapid obsolescence/advance of the technology;
  3. User acceptance;
  4. Lack of high level executive commitment and support; and
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5. Technical difficulties.

- *Costs of technologies*

The cost associated with implementing new technology is prohibitive for many organisations (Tornatzky and Klein, 1982, Venkatesh and Brown, 2001). Many organisations are concerned about technology costs (initial and ongoing costs) during the adoption period as advantages and benefits from technology are implicit and difficult to measure (Gerwin, 1988, Desai *et al.*, 1998). Desai *et al.*, (1998:271) stated that “high cost of development was the only technical barrier perceived as significantly more important than all the other organisational barriers”. The difficulty in quantifying potential benefits of the technology initiatives was also considered a problem. Calculating costs and benefits may turn up to be helpful as a beginning in explaining a business case to address this issue (DOCITA, 1999).

- *Rapid obsolescence/advance of the technology*

The impact of uncertainty in the timing of future innovations critically affects the likelihood of technology adoption (Rajagopalan *et al.*, 1998, Venkatesh and Brown, 2001). Organisations are often reluctant to invest in new technology as they do not recognise the benefits of the financial returns before obsolescence/evolution of that technology (Tornatzky and Klein, 1982, Brancheau and Wetherbe, 1990, Geisler, 1992, Oliver, 1997, Schulman, 1997).

- *User acceptance*

The introduction of new technology can lead to resistance amongst staff (Gould *et al.*, 1991). User acceptance has been considered the critical factor in determining the success or failure of any information technology (Davis, 1989). A lack of an understanding of the technology, lack of capable of employees, lack of communication between IS users and nonusers, lack of training, and perceived complexity can aggravate the situation (Tornatzky and Klein, 1982, Manross and Rice, 1986, Desai *et al.*, 1998). Therefore, it is vital for an organisation to create user awareness and provide appropriate IT skill and knowledge that can

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contributes to the successful adoption of new technology (Brancheau and Wetherbe, 1990, Agarwal *et al.*, 1991, Orlikowski, 1993b).

- *Lack of high level executive commitment and support*

The degree of involvement by senior management is a key factor that influences the successful development, implementation and operation of technology (Brancheau and Wetherbe, 1990, Jeyaraj *et al.*, 2006b). Without the support from senior management, technology cannot be successfully implemented (Manross and Rice, 1986, Cooper and Zmud, 1990, Gagnon and Toulouse, 1996, Desai *et al.*, 1998). High level support and commitment from senior management can avoid and help minimise user resistance to change (Cooper and Zmud, 1990).

- *Technology difficulties*

Lack of understanding of new technology is an important barrier to technology diffusion (Tornatzky and Klein, 1982, Gerwin, 1988, Geisler, 1992, Sharif, 1994, Venkatesh and Brown, 2001). Desai *et al.*, (1998) viewed that technical difficulties were recognised as more important than organisational and strategic barriers. In order to overcome this problem it is important to keep the technology adoption simple and controllable (Sharif, 1994).

### 2.3.4 Technology Acceptance Models

Technology acceptance is defined as an individual's psychological state relate to his or her intended use of a particular new technology (Dray and Monod, 1986). According to Dillon and Morris (1996), successful implementation of technology is one of the most challenging issues face in IS research. Agarwal and Prasad (1997:558) also stated that "having the technology available is simply not enough; it must be accepted and used appropriately by its target user group in order to realise anticipated productivity gains".

During the last two decades of IT research perspective, a significant body of concepts has been examined the determinants of information technology acceptance (Davis *et al.*, 1989, Moore and Benbasat, 1991, Compeau and Higgins, 1995, Taylor and Todd, 1995, Szajna, 1996, Jeyaraj *et al.*, 2006a). Venkatesh *et al.*, (2003) evaluated eight models of user acceptance and formulated a unified

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model that integrates elements across the eight competing technology acceptance models. The nine models under review involved:

- Theory of Reasoned Action (TRA) developed by Fishbein and Ajzen (1975);
- Technology Acceptance Model (TAM) developed by Davis *et al.*, (1989);
- Motivational Model (MM) developed by Davis *et al.*, (1992);
- Theory of Planned Behaviour (TPB) developed by Ajzen (1991);
- Combined TAM and TPB (C-TAM-TPB) developed by Taylor and Todd (1995);
- Model of PC Utilisation (MPCU) developed by Thompson *et al.*, (1991);
- Innovation Diffusion Theory (IDT) developed by Rogers (1983);
- Social Cognitive Theory (SCT) developed by Bandura (1986) and Compeau and Higgins (1995); and
- Unified Theory of Acceptance and Use of Technology (UTAUT) Venkatesh *et al.*, (2003).

Each model is summarised below:

- *Theory of Reasoned Action (TRA)*

The TRA is drawn from the field of social psychology (Fishbein and Ajzen, 1975). This theory was subsequently revised by the Theory of Planned Behaviour (TPB). TRA model is a useful tool to gain deep insight into how attitudes and beliefs are correlated with individuals during the decision making process (Davis *et al.*, 1989, Chang, 1998, Karahanna *et al.*, 1999). An individual's behavioural intention is determined by two constructs: the person's attitude towards behaviour and subjective norm (Fishbein and Ajzen, 1975). TRA is designed to explain virtually any human behavior and should therefore be appropriate for studying the determinants of technology adoption and utilisation (Ajzen and Fishbein, 1980).

- *Technology Acceptance Model (TAM)*

TAM is an adaptation of TRA specifically tailored for modeling the acceptance of information system over more than a decade and is suitable for modeling computer acceptance (Davis, 1993). The model hypothesizes that three variables

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involved perceived usefulness, perceived ease of use and subjective norm are fundamental determinants of user acceptance of technology. A review of research on IS acceptance and usage suggested that TAM has been widely accepted as one of the most influential models in IS research (Davis, 1989, Davis *et al.*, 1989, Robey, 1996, Venkatesh and Speier, 1999). TAM provides a basis for tracing the impact of external factors on internal beliefs, attitudes and intentions (Davis *et al.*, 1989). This model has been used successfully in predicting future technology acceptance behaviour across a variety of new technologies and addressing design problems of new IS before users adopt the technology (Dillon and Morris, 1996, Szajna, 1996). Davis (1989) suggested that this model is simpler and easier to use, that will help them to perform their job better.

- *Motivational Model (MM)*

Motivational theory originally developed in psychology and has been used in IS to explain new technology adoption (Davis *et al.*, 1992). The MM identifies two types of motivation (Extrinsic and Intrinsic) as primary explanation for behaviour (Davis *et al.*, 1992, Vallerand, 1997). For example, Venkatesh and Speier (1999) employed this model to study the influence of pre-training mood on user acceptance of new technology.

- *Theory of Planned Behaviour (TPB)*

The Theory of Planned Behaviour was developed primarily to extend the scope of the TRA so as to predict and explain human behaviour that are largely outside the volitional control of individuals (Ajzen, 1991). This model suggests that the primary determinant of behaviour is intention to engage in the behaviour. Therefore, intention is the major concept of the TPB. Conner *et al.*, (1999:1676) defined intention as a “person’s motivation in the sense of her or his conscious plan or decision to exert effort to perform the behaviour”. Intention is determined by three set of variables involved: attitude toward the behaviour, subjective norm and perceived behavioural control.

- *Combined TAM and TPB (C-TAM-TPB)*

The C-TAM-TPB is a hybrid model which combines the main constructs of TPB with perceived usefulness from TAM (Taylor and Todd, 1995, Venkatesh *et al.*, 2003). The core constructs are attitude toward behaviour, subjective norm, perceived behavioural control and perceived usefulness.

- *Model of PC Utilisation (MPCU)*

The MPCU was drawn from the psychological literature. This model was derived from the theory of attitudes and behaviour proposed by (Triandis, 1977) and adapted for IS contexts by Thompson *et al.*, (1991), who used it to predict personal computers utilisation. In this model, the core constructs that predict PC usage are job-fit, complexity, long-term consequences, affect towards use, social factors and facilitating conditions.

- *Innovation Diffusion Theory (IDT)*

Introduced in 1962, the Innovation Diffusion Theory (IDT) developed by (Rogers, 1983) was used as a framework in IT innovation (Moore and Benbasat, 1991). The IDT provides a conceptual framework in which awareness is viewed as antecedent of user acceptance to the decision to adopt to an innovation (Karahanna *et al.*, 1999). The model aims at predicting the possibility and the rate of an innovation being adopted by different adopter categories (Dillon and Morris, 1996). Moore and Benbasat (1991) stated that Rogers' definition of perceptions are based on perceptions of the innovation itself, and not on perceptions of actually using the innovation. After analysing a variety of previous innovation diffusion studies, Rogers (1983) came up with five general attributes of innovation that impact technology adoption: relative advantage, compatibility, complexity, trialability and observability (Rogers, 1995). More and Benbasat (1991) have expanded upon the five characteristics impacting the adoption of innovations from Rogers (1995) and developed seven constructs (two further constructs) for individual technology acceptance. These seven characteristics of innovation are: relative advantage, ease of use, image, visibility, compatibility, results demonstrability, and voluntariness of use. Other researchers have also

extended Rogers' work by adding two additional factors involved image and trust (Barnes and Huff, 2003).

- *Social Cognitive Theory (SCT)*

The SCT was presented by Bandura (1986) to posit behaviour, personal, and environmental factors operate within an interdependent causal structure. The goal of this model is to examine how these perceptual/cognitive factors help to explain individual behaviour. This model includes four main constructs involved outcome expectations personal, self-efficacy, affect and anxiety that predict computer use and the use of information technology. Self-efficacy plays an important role in determining individual behaviour in using computer (Compeau and Higgins, 1995).

- *Unified Theory of Acceptance and Use of Technology (UTAUT)*

The UTAUT is widely used in the area of information and communication technology acceptance in the workplace. Venkatesh *et al.*, (2003) investigated the key factors of all of the eight models explaining IS usage behaviour and combined the most significant key factors, based on their research. The UTAUT can be seen as a new version of TAM (Louho *et al.*, 2006). The model consists of four key constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions, which are direct determinants of usage intention and actual use behaviour.

While each of the theories/models makes important contributions to the IS literature on user acceptance of information technology, they all focus on users' adoption of new information technologies (or technological innovations) in organisations (Allen, 2000). There are few studies that have examined the adoption of RFID technology from an individual's perspective (Ramachandra, 2005).

## **2.4 RFID Technological Developments**

A substantial volume of literature has been written on RFID as an advancement in wireless technology. While many organisations and researchers have attempted to

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define RFID technology, the consensus is that RFID technology is a wireless technology that uses radio waves to automatically identify, track and trace items (Aberdeen Group, 2004a).

The definition for the terms of RFID is an automatic data capture technology that uses radio transmission to transmit data between reader and receiver. RFID systems consist of electronic devices called RFID tags that can be attached to objects and readers that communicate with the tags via electromagnetic waves (d'Hont and Frieden, 2000). RFID technology allows a wide range of objects including live produce to be identified, tracked, monitored and managed. In comparison with barcodes, major advantages of RFIDs are that they do not require line of sight between tags and a reader in order to be read, tags can be read through non-metallic materials and multiple tags can be read simultaneously (Jones, 1999, Boxall, 2000).

Eight particular aspects of RFID technology will be considered. These are:

- Characteristics of RFID technology;
- Background on RFID technology;
- RFID in supply chains;
- Areas of application of RFID technology;
- Potential benefits of RFID technology;
- Barriers to the adoption RFID technology;
- Return on investment (ROI) of RFID technology; and
- Security and privacy concerns.

### **2.4.1 Characteristics of RFID Technology**

This section will focus on explaining the characteristics of RFID technology. After a brief introduction it will specially focus on explaining the nature of specific attributes of RFID technology.

#### **2.4.1.1 An Overview of RFID Tags or Transponders**

Active RFID tags consist of a microchip that stores up to 10 kilobytes of data, and a coupling element such as a tiny antenna coil, used for wireless communication

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(Sarma *et al.*, 2002). These are available in different shapes, sizes and forms including glass capsules, disks, cylindrical tags, wedge-shaped tags, smart cards and keychain fobs. The price of the tags can vary depending on the operating frequency ranges, data capacity, presence or absence of a microchip and read/write memory (Asif and Mandviwalla, 2005).

Further characteristics of RFID tags are that they can be:

- Read only/read-write; and
- Active/passive/semi-passive.

### ***Read Only/Read-Write***

The data stored in the tags can include product identification, shelf life/expiration, environmental parameters such as temperature, humidity and shock level, as well as handling and storage instructions. The radio tags contain a unique code together with other additional information that may be specified by the user and can be read by the reader or encoder from a distance without contact or line-of-sight (Sarma and Engels, 2003). The tag is activated by a radio signal with a preset frequency and responds with return signal. In read only mode the information can only be read from the tag and cannot be changed. Tags with read only memory are used for tracking inexpensive items (Angeles, 2005). The price of tags with read-write memory is much more expensive than read-only tags because they require rewritable memory.

### ***Active/Passive/Semi-Passive***

The working of RFID systems depend on the type of tag system used. There are three main types of RFID tags which differ depending on whether they have their own power system.

#### ***1. Active Tags***

These tags have their own power source and can transmit signals synchronously over long distances. These tags tend to be heavier and more expensive than passive tags and have an operational life of maximum of 10 years depending upon operating temperatures and battery type (GTTL

502 Term Project, 2002). The tag is activated via a radio wave that causes a signal to be sent back to a reader (Moroz, 2004). Active tags are programmable to transmit at set intervals or when a change of condition occurs. Changed environmental conditions include movement or sensor thresholds such as temperature, humidity, light, gas and shock or any number of sensor detections (Axxcess Inc, 2005).

## 2. *Passive Tags*

These tags do not have their own power and are read via a reader device that sends and receives an electromagnetic signal. They are much lighter than active tags, less expensive and have an operational life of up to 20 years (Accenture, 2001). Passive tags, however, have a shorter distance range (within 10 feet or 3 metres) for the readers than active tags and also require higher powered readers. They do not require any maintenance from users.

## 3. *Semi-passive Tags*

These tags are similar to passive tags but they have their own power and are read via a reader device. Semi-passive tags have a longer read range than passive tags and have a stronger power source that gives them increased functionality for monitoring environmental parameters such as temperature, humidity and shock, however, they are more expensive than passive tags (Accenture, 2001).

Table 2-5 provides a comparative summary of the features of active, passive and semi-passive tags. It includes communications range, sensor capability, data storage, frequency, tag power source, tag battery, required signal strength from tag to reader, cost and life.

**Table 2-5. Summary of Active, Passive and Semi-passive Tags**

Features	Active RFID	Passive RFID	Semi-passive RFID
<b>Communication Range</b>	Long range (more than 100 m)	Shorter range (3 m or less)	15 to 30 feet (100 m)
<b>Sensor Capability</b>	Monitor and record environmental parameters continuously	Sensor and record only when tag is activated by reader	15 to 30 feet (100 m)
<b>Data Storage</b>	Up to 128 KB and another features such as access capabilities	Smaller read/write data storage (128 bytes)	
<b>Frequency</b>	420-450 MHz, 63.57 MHz (Versus)	125 KHz, 13.56 MHz, 920-930 MHz, 2.4-5.8 GHz	915 MHz and 2450 MHz
<b>Tag Power Source</b>	Internal	External transfer by using RF from reader	External to run power the chip's circuitry (tag cannot communicate, just only read)
<b>Tag Battery</b>	Yes	No	Yes
<b>Required Signal Strength from Reader to Tag</b>	Very low	Very high	
<b>Required Signal Strength from Tag to Reader</b>	Very high	Very low	
<b>Type of Memory</b>	Read-write	Mostly read-only	Read-write
<b>Size</b>	Large- to accommodate battery but can be small enough to fit onto a wristband or be wearable	Very small – smallest include tags about the size of a grain of rice and tags of a pencil lead with in diameter and length of approximately ½ inch	Larger than passive tags, but smaller than active tags. Size varies to accommodate battery size. Small enough to wear
<b>Cost</b>	High	Low	High
<b>Life Span</b>	5 year finish	Unlimited life	5-10 years

Source: an adaptation from (Craddock, 2004)

#### 2.4.1.2 Reader or Transceiver

A RFID reader comprises of a radio frequency module, a control unit and an antenna to interrogate electronic tags via radio frequency (RF) communication (Sarma *et al.*, 2002). The RFID reader can be handheld or can be a fixed device. The antenna within a reader generates radio waves from 25 mm to 1.2 m, depending on the power of the reader and the radio frequency (Accenture, 2001). An interrogation zone is the limited region around the reader where it is able to communicate with a tag.

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The readers and tags in an RFID system can communicate on several frequency bands depending on the application and regulatory requirements. Unfortunately there are no frequency standards for most RFID application types. To be able to make interoperability available worldwide, there have been a number of specific frequencies chosen for RFID. These are called ISM frequencies (Industrial-Scientific-Medical). Ten such frequencies are defined, the lowest of these is 6.78 MHz and the highest is 24.125 GHz. Apart from these frequencies everything that falls below 135 kHz is accepted. Low-frequency tags are more suitable for content products with high water content such as fruits, or those that are packaged in tin cans. Users need to choose the correct frequency ranges for their individual application, as each of the frequency ranges has advantages and disadvantages for operation.

Because of the nature of radio frequencies, it is near impossible to produce flawless interlocking interrogation zones. Tags are able to be read sequentially; but sometimes two or more tags signals from one frequency have the ability to cause “reader collision” problems. By using a technique which is called Time Division Multiple Access (TDMA), this problem may be overcome with the readers being instructed to read at different times, rather than both attempting to read at the same time. This ensures that they do not interfere with one another. Further according to Sarma and Engles (2003), frequency hopping can be problematic for RFID. This implies that continuous communication across a frequency cannot be guaranteed and sometimes these gaps create a situation of frequency hopping. While there is little variability in reader design at present, as RFID is implemented in more areas, application software will determine reader functionality (Department of Commerce, 2005). This could include:

- Anti-collision method that prevents readers from reading more than one tag at the same time;
- Verification abilities to ensure that the reader has read all tags; and
- Interference minimising measures between multiple transmitting readers and security measures to prevent unauthorised access to transmitted data (Sarma *et al.*, 2002).

### **2.4.1.3 Antenna or Coil**

The antenna is the most important part of radio communications systems. It converts the electric signal from the reader into the magnetic signal transmitted over the air. Typical reader antenna sizes vary from 5x10 CM<sup>2</sup> up to 50x100 CM<sup>2</sup>. In some systems antennas are built inside a reader device, while in others antennas are external. The wavelength of the radio wave is proportional to the antenna size; the higher wavelength can work at a longer range than the lower wavelength (Hodges and Harrison, 2004).

Finkenzeller (2003) and Sweeney (2005) stated that there are two methods of communicating between readers and tags. These are inductive coupling and electromagnetic waves. With inductive coupling the antenna coil of the reader induces a magnetic field in the antenna coil of the tag. After this happens the tag then uses induced field energy to communicate the data back to the reader. Inductive coupling can only be applied in a few tens of centimetres of communication. With electromagnetic waves the reader emits the energy in the shape of electromagnetic waves. A part of the energy is absorbed by the tag and its circuit turned on. When the tag is alerted, a portion of the energy is then reflected back to the reader. The reflected energy is modulated to enable the transfer of data contained in the tag. The range of communication in an RFID system mostly is determined by the output power of the reader to communicate with the tags (Prasad, 2002).

### **2.4.1.4 RFID Standards**

RFID standards are required to identify performance of tags to guarantee that they meet the intended manufacturing designs (Hodges and Harrison, 2004). Standards also cover the air-interface operational requirements, such as the parameters for interaction between a tag and a reader such as transmission and receiving frequencies; algorithms by which the reader can communicate with the tag; and in case of active tags, when the tags will respond to a reader query (Department of Commerce, 2005).

RFID standards are being developed by standard organisations including international, national, regional organisations and industry or trade association

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level (IDTechEx, 2004b). In essence there are four types of RFID standards based on technical specifications or other precise criteria (IDTechEx, 2004a):

1. Technology standards;
2. Application standards;
3. Data standards; and
4. Conformance standards.

• ***Technology Standards***

These standards deal with the technological features for example, the air interface communications format and data exchange protocols. The technological features have to be able to perform perfectly with different manufacturers or system providers.

• ***Application Standards***

Application standards are defined as those dealing with agreements on the way or ways in which technology or systems are to be used in particular applications to guarantee a consistency in usage in a specified way. While many devices only require technology standards, open systems application standards using data carriers need to ensure that data created at a source has to be completely comprehensible by any, even unknown, recipients.

• ***Data Standards***

Data standards are defined as those dealing with the agreements on the way data is prepared to meet compatibility and interoperability requirements.

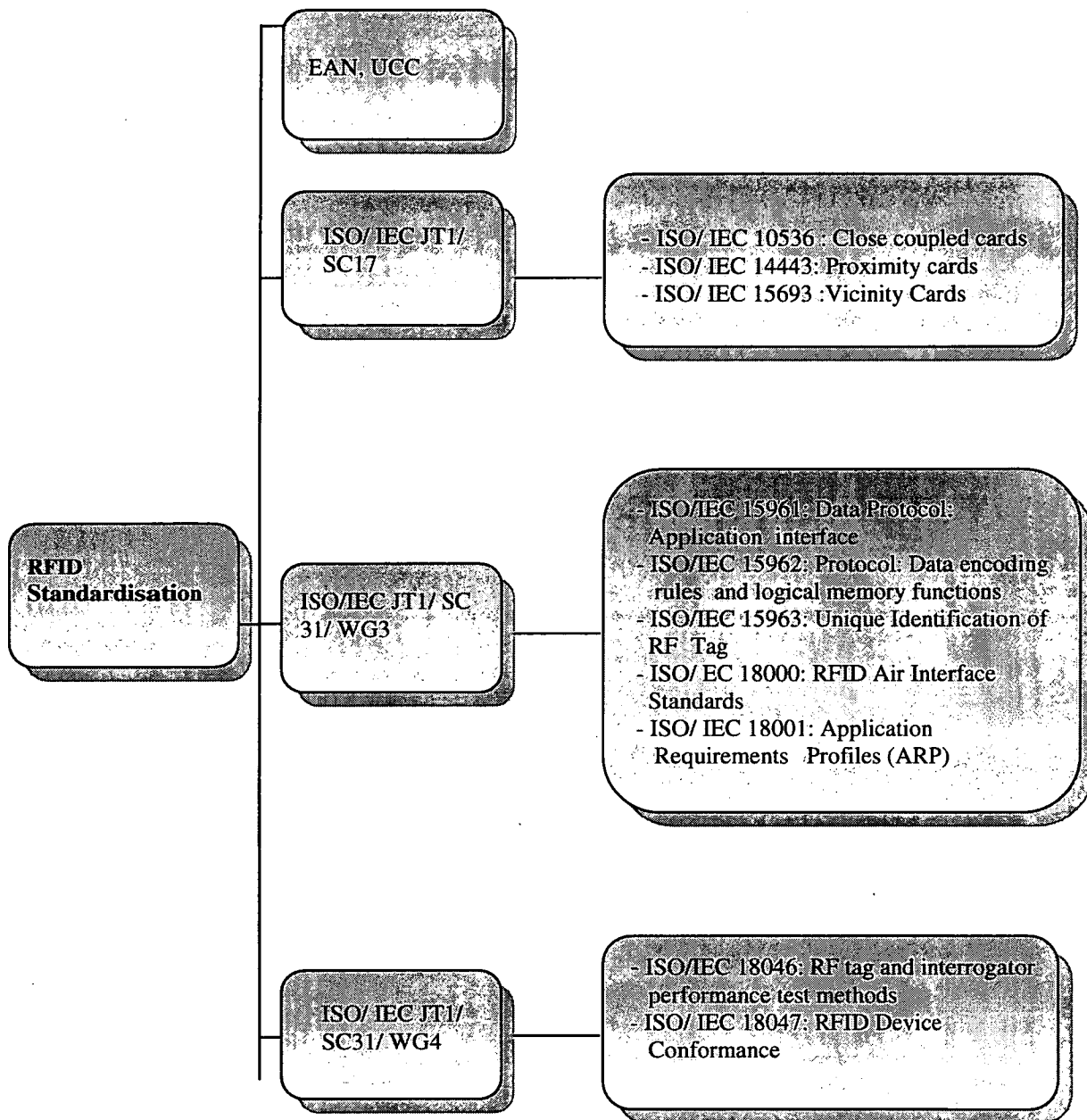
• ***Conformance Standards***

Conformance standards are defined as those dealing with agreements that indicate the manner in which systems are to perform to be suitable with respect to particular performance or operational criteria. The conformance requirements extend to particular regulatory demands with respect to electromagnetic spectrum usage because of the 'radio' or electromagnetic nature of RFID. RFID data carriers (tags or transponders) and related systems may be seen as short range devices (SRD's), sharing spectrum with other short range entities, for example,

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telemetry systems and radio alarms. They must comply (as with any class of spectrum users) with requirements concerning licensed or unlicensed operational parameters, electromagnetic compatibility, interference immunity and safety.

The following figure is a summary of RFID standards from organisations and standards bodies in different areas (Hodges and Harrison, 2004).



**Figure 2-7. A Summary of Current RFID Standards**

Source: an adaptation from (Hodges and Harrison, 2004, IDTechEx, 2004b)

### 2.4.2 Background on RFID Technology

During Second World War the first ideas about RFID were born, as it is a combination of radio broadcast technology and radar. The first RFID device was employed for military purposes during Second World War by the United Kingdom that needed to distinguish returning English airplanes from German airplanes. Veronika and Alexandra (2005) cited in Meyer *et al.*, (2004) reported



that one of the first significant works on RFID is the paper by Stockman, “Communication by Means of Reflected Power”, Proceedings of the IRE in 1948.

RFID has been in commercial use since the early 1980s (Jones, Clarke-Hill, Hillier *et al.*, 2004). In the 1980s there was a full implementation of RFID technology, with interests in the applications differing between Europe and the USA. In Europe the main concern was systems that could be used for animal tracking. In 1987, in Norway RFID was used commercially for the first time to collect tolls (Finkenzeller, 2003). In America, the important issues were industrial and business applications, transportation and personnel access. The 1990s saw a variety of RFID systems being improved and broadened. It has now become part of everyday life (Accenture, 2001). Table 2-6 shows a summary of the history of RFID technology.

**Table 2-6. The Decades of RFID Technology**

Year	Event
1940 - 1950	Radar refined and used major World War II development effort RFID invented in 1948
1960	Early explorations of RFID technology, laboratory experiments
1970	Development of the theory of RFID Start of applications field trials
1980	Explosion of RFID development Tests of RFID accelerate Very early adopter implementations of RFID
1990	Commercial applications of RFID enter mainstream
2000	Emergence of standards RFID widely deployed RFID could become a part of everyday life

Source: (Landt, 2001:7)

### 2.4.3 RFID in Supply Chains

RFID technology has been applied by supply chain participants for more than 50 years (Linster *et al.*, 2004) and has grown to be a very popular topic in supply chain management today (Lee *et al.*, 2004, Lee and Ozer, 2005). The acceptance of RFID as a sophisticated tool for global supply chain tracking has generated commercial interest in supply chain management. It is seen as a suitable alternative for improving supply chain efficiency by providing effective

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communication across the value chain – from the point of harvest to consumer (Accenture, 2004). RFID technology has been able to provide the safety and security of supply chains and improve track and trace ability (Accenture, 2004). Significantly, RFID systems are also capable of combining the data outputs from each location in the supply chain, so that supply chain participants can access data at anytime and from anywhere. These systems also offer an alert system for circumstances where a consignment being transported fluctuates outside of temperature, humidity or other parameters. These alerts can be generated by the system and delivered by Short Message Service (SMS) or E-mail to supply chain participants e.g. truck drivers (DCL, 2006).

Many published papers have discussed the growth of active RFID technology (IDTechEx, 2005, Harrop, 2006). Harrop (2006:1) stated that “active RFID is little reported, but its use is growing rapidly. Value of sales of active systems including the tags will grow from \$0.55 billion in 2006 to \$6.78 billion 2016”. The Department of Commerce (2005) stated that supply chain applications are likely to be the dominant RFID application in the near term. Consumer demand for lower prices is driving companies to make their supply chains more efficient (Department of Commerce, 2005). As RFID has been realised as a substantial part of the worldwide supply chain, World RFID-based Applications market from Frost & Sullivan estimated the value market of RFID, will increase from \$1.7 billion in 2003 to nearly \$11.7 billion by 2010 (Calif, 2004). Another research from the Yankee Group estimated that RFID technology will be a \$4.2 billion market by 2008. A further breakdown of these estimates shows that, over the next three years, manufacturers will spend \$2 billion on RFID tags and another \$1-3 billion on related infrastructure (Barlas, 2004). Although supply chain applications (inventory and warehouse management and product tracking) probably account for the largest dollar value driver of the technology for RFID, a survey of 450 developers around the world, conducted by Evans Data Group, suggests that RFID is currently being used more for security applications.

Twist (2005) pointed out that RFID technology will take a longer time than expected to gain general acceptance because of the increasing complexity of the supply chain. Factors influencing that complexity include the following:

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- Globalisation: more products and components of products are sourced from more countries than ever before, making the supply chain longer and more fragmented;
- Outsourcing of an increasing number of components of the supply chain. From production to transportation to logistics, more entities than ever support the links between the sources of production and the sources of consumption;
- Stock keeping unit (SKU) proliferation: innovations in the supply chain have not previously reduced the need for industrial space as they have been more than offset by increases in new products and configurations; and
- Shorter product life cycles: leading to less historical data on supply and demand and faster changes in product offerings.

#### **2.4.4 Areas of Application of RFID Technology**

Tables 2-7 and 2-8 show a summary of the areas where passive and active RFID technology has been used. These have been reported from a wide range of sources, including industry reports and white papers, with relatively limited work coming from an academic perspective. Despite an extensive search over a long period of time, little evidence could be found in the academic literature that relates specifically to the use of active RFID for time-temperature monitoring in the transportation of perishable food.

**Table 2-7. A Summary of Passive RFID Applications**

<b>Areas</b>	<b>Sources</b>
<b>Access Control/Asset Management</b>	(Aberdeen Group, 2004b, Assetrac, 2006, Lampe and Strassner, 2006)
<b>Animal Tagging/Livestock Management</b>	(Anonymous, 2003a, Brewin, 2003)
<b>Manufacturing, Inventory and Warehouse Management</b>	(Anonymous, 2002b, Kambil and Brooks, 2002, AT Kearney, 2003, 2004, Hanebeck, 2004, Mahadevan, 2004, Weinstein, 2005, Weber, 2006)
<b>Product Security</b>	(Juels and Pappu, 2006)
<b>Prevent Counterfeiting of Products</b>	(FDA, 2004, Staake <i>et al.</i> , 2005)
<b>Supply Chain and Logistics/Shipping Management</b>	(Santeiu, 1994, IBM, 2001, Boushka <i>et al.</i> , 2002, Kambil and Brooks, 2002, Zaharudin <i>et al.</i> , 2002, McFarlane and Sheffi, 2003, Aberdeen Group, 2004c, Anonymous, 2004e, Caton, 2004, Mahadevan, 2004, Penttila <i>et al.</i> , 2004, Porter <i>et al.</i> , 2004, Anonymous, , 2005a, Asif and Mandviwalla, 2005, Avicon <i>et al.</i> , 2005, Borriello, 2005, Bose and Pal, 2005, Collins, 2005, Intermec, 2005b, LogicaCMG, 2005, Pradhan <i>et al.</i> , 2005)
<b>Military Logistics</b>	(AIM, 2004, Gilbert, 2004, O'Connor, 2005a)
<b>Retail</b>	(Agarwal, 2001, Anonymous, 2002b, Chappell, 2002, Kambil and Brooks, 2002, Alexander <i>et al.</i> , 2003b, c, AT Kearney, 2003, Chappell <i>et al.</i> , 2003, Economist, 2003, Anonymous, 2004b, AT Kearney, 2004, Doyle, 2004b, Grocery Manufactureres of America (GMA), 2004, Jones, Clarke-Hill, Shears <i>et al.</i> , 2004, Mahadevan, 2004, Angeles, 2005, Busschop <i>et al.</i> , 2005, Intermec, 2005c, a, Prater and Frazier, 2005)
<b>Cashless Payment, Tracking Consumer Packaged Goods (CPGs)</b>	(Anonymous, 2003d)
<b>Libraries and Video Stores Check-out</b>	(Garofoli and Podger, 2003, Harris, 2003, Schneider, 2003, Anonymous, 2006a)
<b>Tracking Currency/Banknotes</b>	(Juels <i>et al.</i> , 2005, Avoine, 2006)
<b>Tracking Patients/Health Care Industry</b>	(Lawrence, 2004, Wray, 2004, Dempsey, 2005b, Janz <i>et al.</i> , 2005, Krobn, 2005, ActiveWave, 2006)
<b>Tracking Human and Anti-kidnapping Device</b>	(Scheeres, 2003, McCullagh, 2004, Anonymous, 2006b, Romer and Domnitcheva, 2006)
<b>Athletics</b>	(Konkel <i>et al.</i> , 2004)
<b>Parcel and Post Management</b>	(Schell, 2000, Sun Microsystems, 2003)
<b>Baggage Handling and Security in Airports</b>	(Anonymous, 2003b, Wyld <i>et al.</i> , 2005)
<b>Parking Permits</b>	(The University of Arizona, 2006)
<b>Tire Pressure Monitoring</b>	(Anonymous, 2002c)
<b>Prison Security Management</b>	(Anonymous, 2002a)
<b>Food and Beverage</b>	(Anonymous, 2003c, Korolishin, 2003, Thomas, 2003, Clampitt, 2004, Fitzgibbons, 2004, Kevan, 2005, Lombardi, 2005, O'Connor, 2005b, Zebra Technologies, 2005, Anonymous, 2006c, Rice, 2006, Wasserman, 2006)
<b>Construction</b>	(Jaselskis <i>et al.</i> , 1995, Durfee and Goodrum, 2002, Sommerville and Craig, 2005)

**Table 2-8. A Summary of Active RFID Applications**

Areas	Sources
Security and Safety Tracking	(Anonymous, 2004a, Fujitsu, 2004, Axxess Inc, 2005, Griebenow, 2006a)
Health Care Industry	(Dempsey, 2005a, Griebenow, 2006a)
Transport	(Baard, 2005)
Children Monitoring	(Anonymous, 2004c, Best, 2004, O'Connor, 2006)
Cold Chain and Location Monitoring	(Ni et al., 2004, Emigh, 2005)
Military Logistics	(Kevan, 2005, Loudin, 2005)
Hospitality Industry	(Griebenow, 2006a)

### 2.4.5 Potential Benefits of RFID Technology

Since the late 1990s sustained growth in RFID technology has fundamentally changed the global perishable supply chain network. From the literature/white papers, surveys and reports there are a large number of potential benefits to be gained from the implementation of RFID technology. While such literature is available, it often or mostly fails to distinguish between active and passive RFID technology, for example, (Abell and Quirk, 2002, Boushka *et al.*, 2002, Chappell, Durdan *et al.*, 2002, Chappell, Ginsburg *et al.*, 2002, Kambil and Brooks, 2002, Dunlap *et al.*, 2003, Nucleus, 2003, Aberdeen Group, 2004a, c, Accenture, 2004, Grocery Manufactureres of America (GMA), 2004, Jakovijevic, 2004, Pisello, 2004, Psion Teklogix Inc., 2004, Wachter, 2004, Accenture, 2005, AIM, 2005, AIM Global, 2005, Capgemini, 2006). RFID has offered functional benefits at all levels along the supply chain network (Angeles, 2005). As McFarlane and Sheffi (2003:1) have pointed out:

*“Automated Identification (Auto ID) applications can provide corporate information systems with the identity of each physical item in the supply chain in an automated and timely manner. The real time availability of item identity allows other information, related to the item, to be drawn on in order to assess both the current state of the product and future actions required. In the context of supply chain operations, widespread introduction of such systems represents a major opportunity to overhaul*

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*and improve tracking and tracing systems, process control and inventory management. In the longer term, it is possible that Auto ID systems may enable a complete re-engineering of the supply chain, by removing a number of the constraints that limit today's supply chain structures".*

According to Savi Technologies (2006:5-6), "for areas of supply chain visibility requiring additional functionality or flexibility, such as area monitoring, high-speed identification, robust security, or sensor monitoring, Active RFID is required". Griebenow (2006a:2) viewed the benefit of active RFID as "the catalyst for driving pervasive enterprise efficiencies based on the delivery of real-time and complete business intelligence.... data now represented as being displayed in real-time will actually be optimise and allocate resources automatically, ultimately automating the enterprise like never before". Many authors have mentioned the benefits of active RFID technology (Axxess Inc, 2005, Furness, 2006, Griebenow, 2006a, b, Harrop, 2006) as including:

- Provide an automatic alert when tampering occurs;
- Provide automatic notification of a sensor alarming to an out-of-compliance condition;
- Enhance dependability because of high performance;
- Enhance security/access control, including theft reduction;
- Support the linking of tags together in software for custodianship;
- Automate identification and location by removing human intervention;
- Improve data integrity because of accuracy and reliability;
- Improve read accuracy and longer read ranges;
- Provide better monitoring of goods all along entire supply chain;
- Respond to lower level signals than passive systems (which require higher level signals for powering as well as for data communication), thus contributing to greater range capability;
- Support for more processing capability within a tag than is generally associated with passive tags;
- Support more memory and associated data than is generally possible with passive tags; and

- Create competitive advantage in consumer goods, combat the new terrorism, other crime and threatened epidemics of disease.

Other potential benefits of passive tags, identified by researchers include (Brandel, 2003, Atkinson, 2004, Dignan, 2004, Twist, 2005):

- Increase operational efficiency in order to maintain quality assurance of products;
- Reduce food degradation from food contamination e.g. chemical or microbiologically;
- Reduce product recall;
- Enhance the quality and quantity of information on environmental parameters such as temperature, humidity, shock level and duration and location of perishable foods during transportation;
- Improve the effectiveness of traceability;
- Increase security in the distribution channel;
- Improve consignment management;
- Improve efficient and effectiveness of supply chain management;
- Increase controlled product distribution;
- Increase productivity;
- Increase continuous and real-time information;
- Improve data synchronisation;
- Reduce contraband in medications;
- Reduce idle inventory and out-of-stock items;
- Reduce human error and avoid buffer stock. There will be less shrinkage, and charge-backs for inaccurate deliveries and high insurance premium will be avoided;
- Reduce ongoing cost especially labor cost; and
- Reduce need for a middle man.

Active RFID can be used in perishable food distribution as both an operational and strategic technology. For example, over AU\$200 million per year is lost in Australia because of food spoilage (Anonymous, 2004f), largely due to

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temperature degradation through the supply chain. RFID technology provides food companies with the ability to track and trace their produce across the entire supply chain. This aids in maintaining food safety and the adherence to traceability regulations (Rangarajan, 2004). By monitoring temperature and environmental conditions in real-time, the technology can verify the quality of perishable foods as it moves through the cold chain (Foodproductiondaily, 2004b). RFID technology can be a critical component in the distribution of perishable food as its data collected during the shipment is often used in the deciding of whether the product is to be accepted or rejected.

#### **2.4.6 Barriers to the Adoption RFID Technology**

Most of the literature, white papers and reports have been focussed on the use of passive RFID technology within manufacturing, consumer goods/retail business (Agarwal, 2001, Alexander *et al.*, 2002, Kambil and Brooks, 2002, Alexander *et al.*, 2003b, c, a, Kang and Gershwin, 2004, Lee *et al.*, 2004), inventory management applications, logistics and supply chain management (Lee and Ozer, 2005). There is scarcity of published research on RFID in Information Systems (IS) (Asif and Mandviwalla, 2005). A Rai *et al.*, (2006) also noted that there is very little formal academic and practitioner research that has been conducted by the IS community on supply chain management.

- ***Lack of a Global Standard***

The lack of universal standards is a key factor that inhibits the implementation of RFID technology (Cooke, 2001, Anonymous, 2004d, 2006d, Nevshehir, 2006). Over the last few years, the RFID industry has been pushing to create RFID standards (Asif and Mandviwalla, 2005, Twist, 2005). Department of Commerce (2005) stated that interoperability is only possible when there is recognition by readers in countries of tags attached in another country.

- ***Lack of Universal Frequency Ranges***

Use of frequency ranges is one of the most important factors to be taken into account in implementing RFID technology. Twist (2005) stated that costs that have to be addressed include the need to provide the necessary infrastructure to meet technology and communications standards in the frequencies ranges for

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transporting data, in addressing interface issues and responsibility and associated costs related to security and privacy. It is worth emphasising that the issue of standards remains a significant obstacle to widespread RFID implementation (Liard, 2003, Department of Commerce, 2005). This is because numerous different standards and regulations on frequencies and radio spectrum have been adopted in different countries, which in turn has inhibited a global standard for RFID.

• ***Lack of Reliability of RFID Tags***

Reliability of RFID tags also plays an important role in the implementation of RFID technology. Research from the Auto-ID Center suggests that the reliability of RFID readers to communicate with all RFID tags cannot be 100 percent due to environment issues (Dunlap *et al.*, 2003, Nevshehir, 2006). For example, many RFID tags can be read simultaneously yet only one tag at a time can be written to. This presents the problem of not knowing which tag is being read (Finkenzeller, 2003). Pisello (2004) and Juels (2005) stated that RFID tags are affectively liquid, cold storage and metals. Dignan (2004) suggested that products, which are designed to absorb radio waves would affect the reliability of RFID technology, for example, microwaveable containers. Physical effects such as reflection and diffraction can affect RFID tag performance (Department of Commerce, 2005).

• ***Intellectual Property Rights Issues***

A complex and important issue for RFID users and vendors are intellectual property rights (Ashton, 2002). EPCglobal (2003:4) stated that “at this point there is no intellectual property owned by third parties that would block implementation of the new EPC network ”

• ***Lack of Management Enthusiasm, Knowledge and Understanding of the Technology***

RFID technology is a complex technology and is not as simple as bar code technology that has been around in supply chain more than 50 years. RFID technology is the subject of steep learning curves and it takes time for organisations to learn how to effectively use the technology (Sharp, 2006).

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According to Forrester Research, “the technology is not ready, and there is a lack of deep expertise in the industry to help suppliers implant RFID” (Donoghue, 2004:3). Unfortunately, apart from market leaders such as Wal-Mart, only a few pilot tests have been executed in supply chain networks, which is indicative that the maturity of RFID technology still lags behind supply chain participant requirements. As the industry analyst Forrester Research has suggested the technology is still immature and no large-scale investigation of ROI has been announced yet (Department of Commerce, 2005). However, the Department of Commerce (2005) argued that RFID technology is similar to computers, in that the extent of their impact will only be felt after businesses have been afforded the chance to learn about the technology and reconsider their process design before adopting the capabilities offered by RFID.

• ***Lack of Good Data Management***

From an organisational perspective it is evident that RFID technology could have a major impact on supply chain execution. In order to gain the benefits of the technology it is important that the problems need to be overcome as part of the implementation process. For organisations the major challenge is in responding to the information that RFID generates on supply chain management processes. Tracking every object at the individual item level will generate an enormous amount of data that will have to be stored and accessed quickly. Also, there is a question of data ownership once the data are shared across the supply chain (McFarlane and Sheffi, 2003). Unless organisations can respond effectively to the insights that RFID provides by making appropriate changes in the management of their transport processes, the impact of this new technology will not be significant (Hill, M.J. 2003).

McFarlane and Sheffi (2003) viewed that from a technological perspective, there exists the potential for electromagnetic interference with large scale Auto ID networks. This is because RFID technology does not possess its own licensed frequency; rather, it uses several available frequencies. As the accuracy of RFID systems and their underlying information systems become more dependent on real time automated product identity data, the specification placed on the identification system will move towards accuracy that is absolute. The result of this will be the

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creation of new challenges on the engineering and production of the tags and readers. Therefore, decreasing costs, improved education, awareness, standards, and ROI analysis and cost justification are positively impacting the use of RFID technology especially in SME businesses (Liard, 2003, Department of Commerce, 2005).

• **Lack of Demand from Customers**

The key finding from research conducted in the United States with more than one thousand American consumers (Capgemini, 2006) was that Consumer awareness of RFID technology is relatively low at this time. 77 percent of respondents said that they had not heard of this technology before. Consumer willingness to buy RFID and embed in goods was under 25 percent, of which 33.3 percent are not willing to buy.

A summary of the various barriers to RFID technology discussed in this section appears in Table 2-9 below:

**Table 2-9. Summary of Barriers to RFID Adoption**

<b>Organisational Barriers</b>	<b>National Perspective</b>
Lack of knowledge and understanding of the technology	Cost issues
Lack of good data management	Security and privacy concern
Lack of executive sponsorship	Lack of single global standards
Lack of demand from customers	Lack of universal frequency ranges
	Lack of reliability of RFID tag
	Intellectual property rights issues
Source: an adaptation from (Accenture, 2004)	

## 2.4.7 ROI of RFID Technology

Research from Venture Development Corporation (VDC) stated that RFID technology has proved successful in numerous traditional application environments such as security/access control, automobile immobilisation, toll collection and transportation (Liard, 2003). It has not become widely adopted outside traditional RFID application markets (Liard, 2003). The cost/benefit and ROI of adopting this technology needs to be examined carefully (Liard, 2003,

McFarlane and Sheffi, 2003, Lee and Ozer, 2005, Woods, 2005, GS1, 2006). The cost associated with adopting this new technology is prohibitively expensive for many companies (Twist, 2005). Compared to bar codes RFID is an expensive technology (Psion Teklogix Inc., 2004). It is viable to embed RFID tags of high value products by the pallet or the carton instead of by individual products. Dunlap *et al.*, (2003) mentioned about the impact of the cost of tags and readers. Despite their cost, active tags have proven a significant ROI for many applications (Sweeney, 2005).

A substantial volume of literature and conference papers have been written concerning the ROI and payback period (Collins, 2004, Emailwire.com, 2004, Kevan, 2004, Hotchkiss, 2005, Mason, 2005, O'Connor, 2005c, Griebenow, 2006a). However, there are very few articles described in detail how the ROIs or pay back period are derived (Lee and Ozer, 2005). They both go on to say that

*“Although it is common for these reports to claim that the benefits of RFID will come in the form of improved forecasts, reduced inventory, reduced stock outs, and increase revenues, they are not explicit in how these benefits can be arrived at with RFID... Hypes get the attention of senior executives, but they cannot help companies realise the benefits. In the end, frustrated executives may possibly give up and abandon the technology” Lee and Ozer (2005:2).*

ABI Research found that 23 percent of respondents were uncertain about ROI (Collins, 2004). ARC Advisory Group found that 95 percent of respondents expect the ROI/pay back period for RFID would be greater than two years (Emailwire.com, 2004, Purchasing, 2004). However earlier research by Boushka *et al.*, (2002) found that 98 percent of respondents expect ROI within one year. This implies that there is little agreement in expectations of ROI for RFID implementation.

The majority of research on ROI on the usage of RFID have focussed on ROI in passive RFID technology. Griebenow (2006a:2) stated that “the ROI for active RFID is about the total cost of ownership and the myriad of savings categories”.

To date, supply chain participants are considering implementing RFID technology, but most of them have adopted a wait and see approach and trial/pilot test stage in order to allow the RFID market to become mature (Mason, 2005). Liard (2003) viewed that the RFID market has become a waiting game, waiting for standards, waiting for prices to drop, waiting for major orders, and waiting for the market to explode. It has recently been acknowledged that if RFID technology is to proliferate, then it is important that trial blazers in the technology need to make available the results of their pilot studies. Without this information, a barrier to the adoption of RFID could be created (Barthiaume, 2004).

Roberti (2005:2) stated that

*“With RFID, the cost of tags depends heavily on the volume. So as more people adopt the technology, the price comes down. As the price comes down, more applications open up, more companies adopt the technology and that drives the price down further. At the same time, the benefits increase, because the technology becomes cheaper and because companies don’t have to maintain separate inventories and separate business processes. At some point, as costs go down and benefits go up, the two lines intersect. That’s where manufacturers begin to achieve an ROI from using RFID in open supply chains”*

#### **2.4.8 Security and Privacy Concerns**

While RFID technology has potential to improve certain security properties in many applications, it may also increase privacy threats or create new security risks (Sarma *et al.*, 2002). The types of abuses included physical attacks, counterfeiting, spoofing, eavesdropping and traffic analysis. The issue of privacy and security was highlighted in studies as a concern for both individuals and organisations (Twist, 2005). The Department of Commerce (2005) and Juels (2005) have argued that most privacy and security concerns about RFID involve the use of RFID at the individual customer level, at or after the point of sale, rather than in supply and inventory tracking applications. Juels (2006:16) viewed that “RFID privacy and security are stimulating research areas that involve rich

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interplay among many disciplines, like signal processing, hardware design, supply-chain logistics, privacy rights, and cryptography”.

Sarma *et al.*, (2003:12) proposed the security goals as:

*“...Tags must not compromise the privacy of their holders. Information should not be leaked to unauthorised readers, nor should it be possible to build long-term tracking associations between tags and holders. To prevent tracking, holders should be able to detect and disable any tags they carry. Publicly available tag output should be randomised or easily modifiable to avoid long-term associations between tags and holders. Private tag contents must be protected by access control and, if interrogation channels are assumed insecure, encryption. Both tags and readers should trust each other. Spoofing either party should be difficult. Besides providing an access control mechanism, mutual authentication between tags and readers also provides a measure of trust. Session hijacking and replay attacks are also concerns. Fault induction or power interruption should not compromise protocols or open windows to hijack attempts. Both tags and readers should be resistant to replay or man-in-the-middle attacks.”*

Floerkemeier *et al.*, (2006) have considered ways of enforcing RFID compliance with the Fair Information Practices (FIP) of the Organisation of Economic Cooperation and Development (OECD). Their work seeks particularly at informing consumers about the reality and purposes of RFID data collection. Ohkubo *et al.*, (2005:68) also stated that “in order to increase consumer acceptance of RFID technology, RFID advocates must promote and implement comprehensive security measures, along with consumer education, enforcement guidelines, and research in and development of practical security technologies”. EPCglobal has proposed a set of privacy guidelines published in “*Guidelines on EPC for Consumer Products*” that organisations deploying RFID can follow to harmonise existing national and international legislation and regulation dealing with consumer protection, consumer security and privacy concerns as well as other issues (Department of Commerce, 2005, EPCglobal, 2005). Consumer

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advocates, including the Electronic Frontier Foundation, the Electronic Privacy Information Center, and CASPIAN, jointly developed “*the Position Statement on the Use of RFID on Consumer Products in 2003*”(Privacy Right Clearinghouse, 2003).

The barriers of security and privacy concerns discussed so far relate mainly to the individual or consumers more than organisations or industrial perspective (Juels, 2005). Many RFID researchers have suggested a variety of ways to address this issue (Sarma *et al.*, 2002, Inoue and Yasuura, 2006). Among them are the killing of RFID tags at check out point, the use of blocker tags, closed systems, relabelling tags and minimalist cryptography, watchdog tag, RFID Guardian, RFID Enhancer Proxy (REP), trust computing, hash-based lock, and yoking-proof (Sarma *et al.*, 2002, Privacy Right Clearinghouse, 2003, Juels *et al.*, 2005, Good *et al.*, 2006, Inoue and Yasuura, 2006, Juels, 2006a, b, Juels *et al.*, 2006, Karjoth and Moskowitz, 2006, Molnar *et al.*, 2006, Rieback *et al.*, 2006). Juels *et al.*, (2005) stated that it is best to combine all this approaches rather than rely on one single solution.

## 2.5 Summary of Reflections

This chapter has presented an overview of the literature on a range of areas relating to:

- Logistics;
- Perishable foods handling and quality assurance;
- Technological developments; and
- RFID technology.

### *Logistics*

With respect to logistics it established that this plays a major role in a company's supply chain in the sense that it is responsible for the transportation of products to the market place. Logistics has proven to be one of the largest cost elements in the supply chain while it can add value to the effectiveness of the supply chain function from both a cost and a customer service perspectives. ICT has become an important tool to optimise operations in the supply chain. Real time information is

required to ensure that all the processes run smoothly and that the final product is delivered on time at the most economic cost.

In particular, in relation to logistics theory this portion of the review has:

- Provided a background into the broader concept of logistics including the evolution of logistics. In so doing, it has offered an insight into the multiplicity of perspectives it encompasses;
- Demonstrated the range of issues related to logistics activities and expenditure; and
- Provided an insight into logistics in Australia.

### ***Perishable Foods Handling and Quality Assurance***

The review of perishable food handling and quality assurance has highlighted that a considerable body of research has been conducted into issues that mainly address quality assurance of food. The immediate requirements for cold chain logistics management are often the most basic requisites necessary for the movement of perishable goods. These are broadly: environmental factors and those related to track and traceability. It is essential to ensure that the quality assurance and food safety standards are met.

In general the review of perishable foods handling and quality assurance in this chapter has:

- Revealed the importance of these concept to the aquaculture industry in Australia;
- Established an insight into the transportation of perishable foods;
- Demonstrated the wide range of temperature monitoring equipment available; and
- Provided examples of food safety and quality assurance standards applicable in the transportation of perishable foods.



### ***Technological Developments***

This section has highlighted topics relevant for technology diffusion and innovation. In general the review of this section has identified key aspects of technological developments as being:

- Four conceptions of organisation change;
- Evolution of the concept of innovation;
- Innovation decision process; and
- Technology acceptance models.

### ***RFID Technology***

Within this section the nature and characteristics of RFID were described in some detail. This included the notion of active, passive and semi-passive RFID. Further, within this component of the chapter the scarcity of empirical research into the application of active RFID technology was identified.

The review of the literature also raised a number of issues that impact on the ability of researchers to study active RFID technology for quality assurance purposes within perishable food industry. Namely, there is:

- A substantial body of literature concerning the use of passive RFID technology in retail and manufacturing industries. As such there is little direction to examine and explore the use of active RFID technology for time-temperature monitoring within perishable food industries;
- A lack of empirical academic papers focussed on the utilisation of active RFID technology for time-temperature monitoring. Most of the existing literature/papers from a practitioner perspective;
- A lack information of the drivers and inhibitors of RFID usage for quality assurance of perishable food handling;
- Limited experience and understanding of the use of active RFID technology within Australia. This makes it difficult to examine and explore the issues related to RFID technology in this country;
- An absence of existing models of the economic analysis of active RFID technology;

- A scarcity of research exploring the relationship between the use of active RFID technology and organisation change and the methods that can be used to assess and effectively manage these impacts; and
- A revision and emergence of standards applicable to quality assurance in the perishable food industry.

The next chapter will provide a detailed description of the methodology used to gather data to address the objective of this research.

## **CHAPTER THREE: METHODOLOGY**

### **3.0 Introduction**

The aim of this chapter is to explain in detail the research methodology used in the conduct of this research. This research is of an exploratory nature, seeking to explore the development of a benefits model on time-temperature monitoring in the quality assurance (QA) of selected perishable foods. Broadly the structure of this chapter is based on the following sections:

- Philosophical stance;
- Ethics compliance;
- Research methodology;
- Data analysis; and
- Summary of reflections.

### **3.1 Philosophical Stance**

The research presented in this thesis is based on an objective ontology and a post-positivist epistemology. In order to gain a rich insight into the evolving domain of time-temperature monitoring equipment, a research method involving qualitative multiple case studies using semi-structured interviews and critical analysis has been adopted. These approaches are being applied as there is limited availability of data especially quantitative data in relation to this topic. It is also considered the most appropriate method for gathering data from supply chain managers and RFID experts who are involved in the distribution supply chain for the transportation of perishable goods and who have experience in time-temperature monitoring equipment (Neuman, 2000).

#### **3.1.1 The Ontology**

Ontology refers to the assumptions that are made about the nature of the world in which we exist (Avison and Fitzgerald, 1995). Ontology has been defined as “the branch of philosophy that deals with theories about the structure and behaviour of the world that humans perceive” (Wand and Weber, 2004:3). There are two commonly held philosophical positions regarding reality: objectivism and

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subjectivism (Orlikowski and Baroudi, 1991). These opposing stances have significant influence on how a researcher sees the world in the context of their research.

#### **3.1.1.1 Subjective Ontology**

Subjectivist research takes the position that reality is not an absolute, and is derived from the perspectives of those who experience it. The nature of a subjective ontology is one which has numerous and disparate perspectives (Creswell, 1998). In essence, individuals create their own reality, and therefore this belief regarding the research means that there will be differing perceptions because of the experiences and beliefs of those who interact with their action and interactions (Alvesson, 2002).

#### **3.1.1.2 Objective Ontology**

Objectivist research takes the stance that there is one true reality that exists irrespective of biases by the beings that exist within that reality. Objectivism is based on the belief that there is an objective reality that is driven by natural laws and these laws can be uncovered through the application of rigorous research methods (Guba, 1990).

The primary objective of this research is to analyse how the use of time-temperature monitoring equipment increases the quality assurance effectiveness and efficiencies in the logistics of perishable foods management systems. In this research, the aim is to gain a deep insight into the issues and factors surrounding existing technologies and time-temperature monitoring equipment for the transport of perishable foods and to gather the views and opinions of supply chain managers operations regarding their supply chains (Choudrie and Dwivedi, 2005). The examination and understanding of the context in which time-temperature monitoring equipment is used by supply chain managers in order to ensure the quality of products has not been well researched. This research uses a deductive approach to understand how and why processes or phenomena occur. This is an environment in which the experiences of individuals and the contexts of actions are critical (Darke *et al.*, 1998, Silverman, 2001).

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The researcher is seeking an understanding of the justification that can be mounted for the QA of perishable foods by supply chain participants using time-temperature monitoring equipment for QA purposes. This technology is not well developed (Schweber, 2000, Sodha, 2003, Violino, 2004) as the phenomena are dynamic, relatively new and have had relatively little application in the food industry. Also, most of the published research focuses on the use of passive RFID in retail businesses rather than the use of active RFID for time-temperature monitoring in the perishable food industry (Aberdeen Group, 2004a, Ferguson and Taylor, 2004, Angeles, 2005). This is evident in the literature on RFID in logistics where terminology are not yet clear or widely accepted (Darke *et al.*, 1998, Shanks, 2002).

### **3.1.2 Epistemology**

Epistemology is defined as the method in which knowledge is acquired, it refers to “how we know” (Hirschheim, 1985, Neuman, 2000). The predominant epistemologies used in IS research are positivist (Guba and Lincoln, 1994), interpretivist (Orlikowski and Baroudi, 1991) and critical social science (Ridley and Keen, 1998). In the research presented in this thesis the chosen epistemological position of the researcher is post-positivist. A brief discussion of positivist and interpretivist approaches follows. The post-positivist approach and its relevance for this research are then discussed in greater detail.

#### **3.1.2.1 Interpretivist Epistemology**

Interpretivists believe that a problem should not be viewed subjectively and reduced to its constituent parts for study. The researcher believes that the interactions of people within a setting or situation, are fundamental to the research (Orlikowski and Baroudi, 1991). Interpretivists assume that “knowledge and meaning are acts of interpretation, hence there is no objective knowledge which is independent of thinking, reasoning humans” (Gephart, 1999:6). The ontological assumptions of the interpretive perspective are based on subjectivity. Within the interpretivist paradigm, epistemological assumptions are based on the belief that there are multiple realities or relativity. Interpretive research focuses on the complexity of human sensemaking, as the situation emerges. It attempts to understand phenomena through the meanings people assign to them.

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Understanding social reality requires deriving constructs from the field by a detailed examination of an exposure to the phenomenon of interest. More significantly, interpretive methods of research within the IS community are aimed at producing an understanding the context of the IS and the process by which the IS influences and is influenced by that context (Klein and Myers, 1999). The fundamental difference between the interpretist and positivist paradigms is that interpretivism emphasises our knowledge of reality, which are social products and therefore must be recognised through the eyes of the social actors involved in the construction and sense making of that reality including the researcher (Orlikowski and Baroudi, 1991).

### **3.1.2.2 Positivist Epistemology**

In the discipline of IS, authors such as Orlikowski and Baroudi (1991) and Neuman (2000) have identified that the positivist approach was the most dominant. The positivist paradigm is based upon scientific theory where predictions can be empirically disproven, for example, shown to be wrong. Positivism has an emphasis on experimental scientific observations to explain and test cause-effect relationships of an event (Creswell, 1994, Neuman, 2000). Therefore scientific theory, from a positivist view, seeks to elaborate or falsify the predictions of existing theory. Positivism deals with facts and these equate with what we can observe. Positivism suggests that phenomena are observable, explainable and measurable in quantitative terms. It is a theoretical paradigm with an ontological stance (worldview) that assumes universal truths and laws are able to explain and predict behaviours and events. The paradigm is designed to eliminate subjectivity and is not about opinions or judgements. Therefore it is suitable if there exist testable hypotheses, quantified variables and the ability to draw inferences about a population from a sample of that population (Orlikowski and Baroudi, 1991).

Within the positivist paradigm, epistemological assumptions are based on the pursuit of realism through the empirical testing of theories based on deduction (Layder, 1993). The use of this hypothetic-deduction allows for statistical generalisation to be tested, with findings being considered as true (Guba and Lincoln, 1994). The principle data collection techniques include experiments and

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sample surveys that are outcome-oriented and assume natural laws and mechanisms. Data collection for positivism is carried out with the researcher being remote from the phenomena under investigation. That is, the researcher operates in the position of the recover of data and he/she discovers the truth that is considered to an undeniable character (Anderson, 1990).

The positivist philosophy has been criticised for disregarding historical and contextual conditions as possible influences on human actions and social interaction. Adopting a positivist stance may not assist the researcher in understanding the actions of a research subject fully as this disregards the contextual conditions (Orlikowski and Baroudi, 1991). A further criticism and possible weakness of the positivist philosophy is that the intention to explain and predict social reality. The positivist stance uses research techniques that encourage deterministic explanation of phenomena, while often searching for a causal explanation to a problem (Orlikowski and Baroudi, 1991).

### **3.1.2.3 Post-positivist Epistemology**

As a result of the limitations of positivism an alternative perspective has arisen post-positivism (Fischer, 1998, Racher and Robinson, 2002). While the positivist epistemology deals only with observed and measured knowledge the post-positivist epistemology recognises that such an approach would result in making many important aspects of sociology irrelevant because feelings, beliefs and perceptions cannot be readily measured. The post-positivist epistemology regards the acquisition of knowledge as a process that is more than mere deduction. Knowledge is acquired through both deduction and induction. Gephart (1999:5) stated that:

*“Post positivism is consistent with positivism in assuming that an objective world exists but it assumes the world might not be readily apprehended and that variable relations or facts might be only probabilistic, not deterministic. Thus the positivist focusses on experimental and quantitative methods used to test and verify hypotheses have been superceded or complemented to some extent by an interest in using*

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*qualitative methods to gather broader information outside of readily measured variables”.*

While the researcher is striving for correctness and completeness in the gathering and analysis of the data, it is recognised that the knowledge of experts and the analysis techniques are imperfect and cannot produce an absolutely correct model of the impact of the adoption of time-temperature monitoring technology (Fischer, 1998, Phillips and Burbules, 2000). As Phillips and Burbules (2000:31) have stated, “acceptance of the possible imperfection and fallibility of evidence is one of the central tenets of post-positivism”. Further, the adoption of a critical realism approach allows the researcher to accept that some things are tangible, measurable and knowable, and other things are intangible, may not be measurable and knowable in detail.

Post-positivist analysis of case studies can employ qualitative methods as follows:

- Post-positivist case study analysis can be applied to the development of economic models, within the scope of the cases being considered (Phillips, 1990, Patomaki, 2000, Trochim, 2002a, Demetron, 2004);
- A range of qualitative modes of analysis can be employed: pattern-matching, explanation-building, effect-outcome explanatory matrices, critical analysis and analytic model construction (Yin, 1994);
- Deductive analysis can be used to formulate propositions and then critically evaluate these propositions against the available data. These propositions are natural language explanations of the effect-outcome relationships identified and form the basis for specification of models of relationships between identified independent and dependent variables or *laws of interaction* (Shanks, 2002);
- Specific techniques to be employed are: identification of key dependent and independent variables, characterisation of the relationships between variables, and formalisation of the relationships as propositions;
- The researcher aims at giving a description of the cause and effect model which is more precise, aiming to be able to give a quality empirical explanation of the social scientific process (Fischer, 1998);



- An outcome is the development of normative models of behaviour, which can be expressed as models of relationships between identified independent and dependent variables (Alexander and Reed, 2006);
- The researcher seeks to establish procedures and criteria that can support commonly adjudicated truth claims from participants that do not depend solely on those subjectively experienced or believed realities (Phillips and Burbules, 2000); and
- The researcher makes the effort to detect and eradicate bias by attempting to tease out the valid from the invalid uses, as well as try to benefit from error and improve the validity of the research (Phillips and Burbules, 2000).

Table 3-1 shows a summary of the key characteristics of three epistemological paradigms.

**Table 3-1. Key Paradigms and the Features of the Three Research Paradigms**

	<b>Positivism</b>	<b>Interpretivism</b>	<b>Post-positivism</b>
<b>Assumptions</b>	Objective world which science can mirror with privileged knowledge	Intersubjective world which science can represent with concepts of concepts of actors; social construction of reality	An objective world exists but one's ability to observe and interpret that world is limited; what is obvious to one is not so to another
<b>Key Focus or Ideas</b>	Search for contextual and organisational variables which cause organisational actions	Search for patterns of meaning	Search for observable and warranted causal relationships
<b>Key Theories in Paradigm</b>	Contingency theory; systems theory; population ecology; transaction cost economics of organising	Symbolic interaction; ethnomethodology; phenomenology; hermeneutics	Contingency theory; systems theory; relevant economic theory
<b>Goal of Paradigm</b>	Uncover truth and facts as quantitatively specified relations among variables	Describe meanings, understand members' definitions of the situation, examine how objective realities are produced	Seek to develop warrants that are substantiated by one's perceived understanding of the objective world
<b>Nature of Knowledge or Form of Theory</b>	Verified hypotheses involving valid, reliable and precisely measured variables	Abstract descriptions of meanings and members definitions of situations produced in natural contexts	Conjectures and propositions, based on warrants that are circumstantial or situational, derived from interpretations of the objective world

	Positivism	Interpretivism	Post-positivism
<b>Criteria for Assessing Research</b>	<ul style="list-style-type: none"> <li>• Statistical criteria</li> <li>• Reliability</li> <li>• Validity</li> <li>• Sample size</li> <li>• Common methods bias</li> <li>• Sampling error</li> </ul>	<ul style="list-style-type: none"> <li>• Trustworthiness (credibility, transferability, dependability and confirmability)</li> <li>• Authenticity (fairness and ontological, catalytic and tactical authenticity)</li> </ul>	<ul style="list-style-type: none"> <li>• Statistical criteria</li> <li>• Reliability</li> <li>• Validity</li> <li>• Sample size</li> <li>• Common methods bias</li> <li>• Sampling error</li> <li>• Acknowledge of limitations</li> </ul>
<b>Unit of Analysis</b>	Variable	Meaning; symbolic act	Variable
<b>Research Methods and Type (s) of Analysis</b>	Scientific method	<ul style="list-style-type: none"> <li>• Case studies</li> <li>• Conversational and textual analysis</li> <li>• Expansion analysis</li> </ul>	Scientific method, interpretation, critical analysis
<b>Type of Data</b>	Quantitative and Quantitative	Qualitative	Qualitative and Quantitative

Source: an adaptation from (Guba and Lincoln, 1989, Phillips, 1990, Gephart, 1999, Patomaki, 2000, Phillips and Burbules, 2000, Racher and Robinson, 2002, Alexander and Reed, 2006)

This research adopts a post-positivist approach. This approach has been adopted due to the lack of established theory in this area and the limited sources of data, especially a lack of quantitative data (Fischer, 1998). Therefore the researcher needs to rely on the material gathered from experts through case studies. Rapport building with participants was critical to the effectiveness of the information gathering, so that participants would be forthcoming in providing rich information.

### 3.1.3 Rigour in Post-positivist Case Study Research

Rigour deals with the extent to which the application of a research methodology follows accepted research practices. Reliability measures how dependable are the outcomes (Morse *et al.*, 2002). The particular issue of the rigour of post-positivist research in Information Systems (IS) is important when looked at in the larger context of the findings being accepted and therefore made available to a wider audience (Darke *et al.*, 1998). One approach could be to argue the case within a post-positivist research approach; another is to grow the body of literature on research approaches and concurrently develop standards that, if adopted, can be used to claim rigour for the particular research in question. Mentzer and Flint (1997) viewed that rigour is central to logistics research, as the issues considered and the techniques used to examine these issues become more sophisticated. Mentzer and Flint (1997) stated:

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*“Rigour is of even greater importance as logistics researchers and managers begin to examine not only the traditional operational aspects of logistics, but the more behavioral customer satisfaction and relationship management issues as well” (Mentzer and Flint, 1997:200).*

Authors in the field of IS, including Benbasat *et al.*, (1987), Eisenhardt (1989), Lee (1989), Silverman (1993), Miles and Huberman (1994), Yin (1994), Darket *et al.*, (1998), Shanks (2002), Dubé and Puré (2003) have identified the need for greater rigour in case research using qualitative approaches. The term rigorous, reliability, validity and trustworthiness have become increasingly important within the qualitative paradigm (Kirk and Miller, 1986, Guba and Lincoln, 1989, Morse *et al.*, 2002, Denzin and Lincoln, 2003, Seale, 2004). Kirk and Miller (1986), Guba and Lincoln (1989), Denzin and Lincoln (2003) noted that within the rationalistic paradigm, the criteria to reach the goal of rigour are internal validity, external validity, reliability, and objectivity. On the other hand, the criteria in the qualitative paradigm is to ensure trustworthiness, credibility, fittingness, auditability, and confirmability (Guba and Lincoln, 1981). These criteria were quickly refined to; credibility, transferability, dependability and confirmability (Lincoln and Guba, 1985).

According to the study by Morse *et al.*, (2002), without rigour, research is worthless, becomes fiction, and loses its utility. Morse *et al.*, (2002) also suggested that the qualitative researcher should focus on strategies to establish trustworthiness at the end of the study, rather than focus on processes of verification during the study. In order to achieve this, the researcher runs the risk of missing serious threats to the reliability and validity until it is too late to correct them. It has been acknowledged by Dubé and Paré (2003) that the achievement of a higher level of rigour is needed in scientific research. In order to be considered an accepted methodology and to add to the growth of knowledge in a field, positivist case research must pass the tests of scientific rigour. Yin (1994) stated that the two tactics which can ensure reliability are the use of a case study protocol and the development of a case study database. The ways in which the quality of such positivist studies are judged, as opposed to interpretive and critical case studies, are related to the tests of traditional validity and reliability used in

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the natural sciences (Yin, 1994). Limitations of credibility, transferability, dependability and confirmability are commonly linked to discussion of the trustworthiness of qualitative studies (Adler and Adler, 1994, Denzin and Lincoln, 2000, 2003). Hammersley (1992) cited in Seale (2004) has proposed three broad issues that need to be raised when assessing the quality of research:

1. How important or relevant the topic is for some community;
2. Whether the claims made are plausible, given our existing knowledge about the subject; and
3. Whether the credibility of the claims is supported by sufficient evidence. It is of course, this last point that is the most crucial in determining quality, being the “inner” dialogue that the researcher must conduct (Seale, 2004).

Seale (2004) proposed four techniques to improve the quality of research that involved learning from philosophy, social theory, methodology and practice. He pointed out that the quality of research can be improved by learning from mistakes or clever things and also reading methodological writing from the research of others. Kirk and Miller (1986) suggested that objectivity is the essential basis of all good research, together with the simultaneous realisation of as much reliability and validity as possible. Guba and Lincoln (1989:235) pointed out the definition of objectivity “responds to the positivist demand for neutrality, and requires a demonstration that a given inquiry is free of bias, values and/or prejudice”. However, Patton (1999) stated that neutrality and impartiality are not easy stances to achieve. For assessing the criteria of a credible, high-quality analysis there are no simple formulae (Patton, 1999). However, Silverman (1993) argued that for the purposes of social research, it may simply not be useful to conceive of an over-arching reality to which the data, gathered in different contexts, approximates.

### **3.1.3.1 Validity and Reliability**

Definition of validity and reliability have been covered by Goetz and LeCompte (1984), Kirk and Miller (1986), Hammersley (1990), Dunn *et al.*, (1994), Mentzer and Kahn (1995), Mentzer and Flint (1997), Lincoln (2003). According to Maxwell (2002), validity can be defined in a broad sense as something that

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pertains to the relationship between an account and something outside of the account. This can be constructed as objective reality, the constructions of actors or a number of other interpretations. Dunn *et al.*, (1994), Mentzer and Kahn (1995), Mentzer and Flint (1997) have widely addressed validity in logistics research. Mentzer and Flint (1997) see validity in research as a hierarchy of procedures that ensure that what we are able to conclude from a research study that what is stated has a degree of certainty. Maxwell (2002:48) gave his opinion on reliability as “in my view, reliability refers not to an aspect of validity or to a separate issue from validity, but to a particular type of threat to validity”.

Patton (1999) viewed that an obligation of the qualitative researcher is to be methodical by reporting sufficient details of data collection and what processes were used. This is, to enable others to determine the quality of the resulting product. In an effort to address issues of validity in qualitative approach, Hammersley (1990), Hammersley (1992), Silverman (1993) developed a "subtle form of realism". Emphasis was placed on the dependence on human relevance, in assessing the relevance of a study and judging its validity. Hammersley (1992), Silverman (1993) stated that social science would be lacking in value if its findings did not have some relevance to people outside the research community, and identified three elements as:

1. Validity is identified with confidence in our knowledge but not certainty;
2. We can assume that reality is independent of the claims that researchers have made about it; and
3. At all times, reality is viewed through particular perspectives; therefore, whilst our accounts represent reality, they do not produce it.

The discussion by Campbell (1957) of validity is useful, especially his itemisation of the threats to validity and that the distinction between internal and external validity is fundamentally misleading. This opinion is supported by Hammersley (1991) as he feels there exists some ambiguity about the meanings of the terms “internal” and “external” validity. Denzin and Lincoln (2003) considered how internal and external validity in qualitative procedures can lend themselves to structured analysis. Although reliability is necessary to have a valid measure of a

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concept, it does not guarantee that a measure will be valid. Therefore reliability is not a sufficient condition for validity (Neuman, 2000).

Yin's (1994) view of the principle of research is that it is to enable an external reviewer or observer to follow the source of any evidence from the initial questions to the ultimate case study conclusion. Yin (1994) recommended that the reader of the case study should have no trouble following the source of any evidence from initial research questions to the conclusions of the study. The reliability of the findings can be improved by using this chain of evidence. In an attempt to achieve this, some findings of this present research were accepted for presentation at a conference in Germany after being subjected to blind, peer review process (Keen and Thamworrawong, 2006). The aim of reliability is the minimisation of errors and biases in a study, and this is able to be achieved by conducting the case research in an effort to enable an investigator to repeat the procedures and to arrive at the same conclusions. Benbasat *et al.*, (1987) stated that the case study researcher needs to give definitive descriptions of where their topics slot into the processes of knowledge building. They should also detail the case selection criteria and provided detailed information about the process of data collection.

Stake (1995), on the other hand, indicated that qualitative approaches raised issues that relate to reliability and validity. Dubé and Paré (2003) pointed out that when building theories from case research, there is a strong need to compare the emergent concepts and theory against the existing literature. Eisenhardt (1989) concluded from an examination of the literature that there is in conflict with the emergent theory and a likelihood that confidence will be enhanced in the findings. Eisenhardt (1989) stated that there is a need for sufficient quotes to be presented in case reports in order to enable an external observer to reach a judgment that is independent in regards to the merits of the analysis. There will be an increase in the confidence in the case findings (generalisability and internal validity) through the comparison of findings with both conflicting and similar literature. Benbasat *et al.*, (1987) recommended criteria in order to increase reliability and validity of the case research methods:

- Provide detailed information about the research objectives and research plan;
- Provide reasons for the selection of a multiple-case design;
- Provide the reasons for the choice of particular sites with determined by the design approach;
- Provide clear data collection methods and details; and
- Use triangulation to increase reliability.

Eisenhardt (1989), Johnson (1997), Neuman (2000), Maxwell (2002) have proposed that the following forms of validity are appropriate to qualitative research:

- Statistical conclusion validity;
- Internal validity;
- Construct validity;
- External validity;
- Descriptive validity;
- Interpretive validity;
- Theoretical validity; and
- Evaluative validity.

• ***Statistical Conclusion Validity***

Statistical conclusion validity refers to whether, between two phenomena, there is a statistical relationship. This can be determined through the measuring and varying of two things (e.g. X and Y) in a research study to achieve statistical conclusion validity (Mentzer and Flint, 1997). Cook and Campbell (1979) stated that qualitative researchers should consider instability as one of the major threats to statistical conclusion.

• ***Internal Validity***

Internal validity is defined conventionally within the positivist paradigm as the extent to which variations in an outcome or dependent variable can be attributed to controlled variation in an independent variable (Cook and Campbell, 1979,

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Lincoln and Guba, 1985, Mentzer and Kahn, 1995). Guba and Lincoln (1989:234) stated that “assessing internal validity is the central means for ascertaining the truth value of a given inquiry, that is, the extent to which it establishes how things really are and really work”. Establishing truth value involves asking the question; “how can one establish confidence in the truth of the findings of a particular inquiry for the subjects with whom and the context in which the inquiry was carried out?”(Guba and Lincoln, 1989:234). If a qualitative description or analysis is not true or false, then the issue of whether that description or analysis is to be believed or acted upon cannot arise (Phillips, 1987). In order to believe or disbelieve and in order to be the basis for decision making, it is absolutely necessary to have the property of being true or false. High internal validity means there are few such errors. Low internal validity means that such errors are likely (Neuman, 2000).

• ***Construct Validity***

Construct validity is made up of several forms of supporting validity. Yin (1994) suggested three techniques that enhance construct validity involved multiple sources, chain of evidence and review with participants. It also embodies the process of theory development and testing. Mentzer and Flint (1997) posed the question of how it is possible to be certain that our theoretical phenomena have been correctly defined and measured in study and pointed out that this is the question that construct validity addresses. In order to measure the construct in a research study, it is necessary for us to have empirical correspondence, meaning the operationalised measures we have selected are reasonable accurate measures of the corresponding theoretical constructs. The process of construct validity was important in the data gathering and analysis phases of this research. The participants were asked to check the transcripts of interviews for errors or misrepresentations. This procedure ensured a level of participant validity was maintained throughout the research (Bronfenbrenner, 1976). Thus construct validity could be maintained by comparing the feedback with cause and effect analysis, as well as pattern matching. Trochim (2002a) stated pattern matching is the heart of construct validity.



• ***External Validity***

External validity can be defined in the positivist paradigm as “the approximate validity with which we infer that the presumed causal relationship can be generalised to and across alternate measures of the cause and effect and across different types of persons, settings and times” (Cook and Campbell, 1979:37). Guba and Lincoln (1989:234) stated that external validity has as its purpose a response to the applicability questions: “how can one determine the extent to which the findings of a particular inquiry have applicability in other contexts or with other subjects”. External validity is concerned with the generalisability of study findings, its relevance to practical and political projects, its consequences, uses and overall purposes (Campbell and Stanley, 1966, Seale, 2004).

In this research there is no claim of generalisation of the application of the findings beyond the scope of the five case studies considered. This is consistent with post-positivist epistemology not to assert any universal theories that are not substantiated by the data obtained in these studies.

• ***Descriptive Validity***

Descriptive validity is used to describe the accuracy in the reporting of descriptive information (Johnson, 1997). That is, the researcher is not making up or distorting the things they saw and heard or touched or smelt. The second aspect of descriptive validity is the validity of accounts of things that could in principle be observed (Maxwell, 2002).

To achieve greater descriptive validity in this research digital recordings will be used to determine the accuracy of data, also pattern matching will be employed.

• ***Interpretive Validity***

Interpretive validity is defined as “the degree to which the research participant’s viewpoint, thoughts, feelings, intentions, and experiences are accurately understood by the qualitative researcher” Johnson (1997:284). Winter (2000:5) stated that “interpretation is typically viewed as an inextricable (and, indeed, unavoidable) element of data collection”. Maxwell (2002:49) pointed out that

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“interpretive accounts are grounded in the language of the people studied and rely as much as possible on their own words and concepts” Like descriptive validity, interpretive validity is dependent upon consensus with the relevant community, and the concepts and terms employed are close to experience. He added that interpretive validity does not only apply to the conscious concepts of participants; it can also relate to the unconscious intentions, beliefs, concepts and values of these participants.

In the research presented in this thesis the language issue in the semantic analysis of the research is one of the issues related to interpretative validity.

• ***Theoretical Validity***

Theoretical validity refers to how much a theoretical explanation developed to explain the data actually fits the data. Theoretical validity is “concerned with problems that do not disappear with agreements on the facts of the situation” (2002:51). Cook and Campbell (1979) pointed out that there are two aspects to theoretical validity: the validity of the concepts and categories applied to the phenomena, and the validity of the postulated relations among the concepts. The first of these aspects of theoretical validity is very similar to what is generally known as construct validity. The second aspect includes, but is not limited to, what is known as internal or causal validity. Maxwell (2002) viewed that the previous two accounts of validity are dependent upon an agreement on the application of terms and that disagreements refer only to accuracy and not meaning. He goes on to say that theoretical validity goes beyond the concrete and descriptive and concerns itself with the constructions that researchers apply to, or develop, in the process of the research.

• ***Evaluative Validity***

Evaluative validity looks at the issues of the application of ethical or moral frameworks and judgements in an account. According to Maxwell (2002), evaluative frameworks are alike in both qualitative and quantitative research, and that a great deal of researchers does not claim to apply any evaluation to their research at all. However, evaluation, however, is not some conclusive statement

that may or may not be tagged onto the end of a research report, therefore estimating the nature, outcome or reality of that research (Maxwell, 2002).

Table 3-2 shows a summary of how the issues of validity have been addressed in the current research project.

**Table 3-2. Methods Used to Account for Validity in this Research Project**

<b>Criteria</b>	<b>Approach Taken in this Research</b>
<b>Statistical Conclusion Validity</b>	This criterion is not relevant, due to the limited availability of data and the use of qualitative analysis techniques
<b>Internal Validity</b>	This criterion is addressed through the rigorous grounding of effect-outcome relationships in the data
<b>Construct Validity</b>	This criterion is addressed by the use of participant review and validation
<b>External Validity</b>	No claim is made of generalisation of the findings of this research beyond the case studies examined
<b>Descriptive Validity</b>	This criterion is addressed through the use of recorded interviews, copies of gathered documentation, two people attending each interview and participant review of notes of each interview
<b>Interpretive Validity</b>	This criterion is addressed through the use of recorded interviews and semi-structured interviews that sought to clarify and confirm the participants' views
<b>Theoretical Validity</b>	This criterion is addressed through grounding of the analysis in the data peer review of the researcher of the validity of the construct derived from the data
<b>Evaluative Validity</b>	This criterion is addressed through adoption of a rigorous methodology, respect of the integrity of the participants, and rigorous grounding of the findings in the data

Source: an adaptation from (Aedy, 2004)

Based on the previous section, for the purposes of the research reported in this thesis, the following forms of validity will be addressed:

#### ***Validity and Reliability of Interview Data***

In this research post interview contact was made with all involved in order to confirm the content of the interviews, with the interviewees being given the opportunity to proof read the transcripts in an effort to eliminate any distortion of content. According to Bryman (1988), Silverman (2001), this procedure enables a level of validity that can be maintained during the research with each of the case study participants. Before the beginning of the interview processes some research was done by the researcher on the background of each interviewee in an effort to avoid the problem of anecdotalism (Bryman, 1988, Silverman, 2001).

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During the interview and transcribing processes the researcher kept all information between interviews and interviewers in an effort to increase the reliability of the interpretation of the transcripts (Silverman, 2001). Bryman (1988) noted that field notes or extended transcripts are not normally published. If these were readily available the reader would be more likely to be able to formulate his or her own opinion about the perspective of the people who have been studied. Silverman (1993) viewed that transcript of such recordings, based on standardised conventions, are able to provide high quality records of “naturally occurring” interaction. Recordings and transcripts are more likely to offer records that are highly reliable than field notes of observational data. However, in the current research the research ethics agreement signed by the researcher required that the identity of the participants and the details of all interviews be kept strictly confidential. Poland (1995) stated that developing the trustworthiness of the transcripts is an essential component of rigour in qualitative research. He pointed out that the researcher needs to spend time listening to the recorded interviews and accurately interpreting variances in voice tones of the participants. To achieve this, all interview transcripts were read concurrently with listening to the digital recordings.

### **3.1.3.2 Trustworthiness**

Lincoln and Guba (1985) and Yin (1994) stated that “trustworthiness” is one dimension of perceived methodological rigour and a goal of the research. Lincoln and Guba (1985) proposed four criteria for judging the trustworthiness of qualitative research and explicitly offered these as an alternative to more traditional quantitatively-oriented criteria. They are credibility, transferability, dependability and conformability. In addition, these concepts determine specific methodological strategies for demonstrating qualitative rigour, such as the use of audit trail, member checks when coding, categorising, confirming results with participants, peer debriefing, negative case analysis, structural corroboration, and referential material adequacy (Guba and Lincoln, 1981, Lincoln and Guba, 1985, Guba and Lincoln, 1989, Lincoln and Guba, 2002). Guba and Lincoln (1989) developed authenticity criteria that were unique to the constructivist assumptions and that could be used to evaluate the quality of the research beyond the methodological dimensions (Guba and Lincoln, 1989). According to Guba and

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Lincoln (1981), to be able to be deemed worthwhile, the nature of knowledge that lies within the rationalistic paradigm differs from the knowledge in naturalistic paradigm. According to Schatzman and Strauss (1973), the more "naturalistic" the evaluation is, the more it depends on its audiences to reach their own conclusions, draw their own generalisations, and make their own interpretations. Morse *et al.*, (2002:9) also stated the problem of trustworthiness is "while strategies of trustworthiness may be useful in attempting to evaluate rigour, they do not in themselves ensure rigour".

### 3.1.4 Data Collection Approach

The opportunity to be able to access an array of different sources of evidence is a major strength of case study data collection. A mix of qualitative and quantitative data increases the opportunity to be able to use many different sources of evidence to provide a richer picture of the events and/or issues than would any single method (Yin, 1994). This enhances the richness of the data and more valid allows greater flexibility in the research design and the mixing of qualitative and quantitative approaches (Yin, 1994, Mingers, 2003). Yin (1994) viewed that by using similar methods of data collection and analysis, a comparative approach can be achieved when analysing and discussing findings. However, Yin (1994) mentioned that case study research is both holistic and flexible and this could result in a lack of focus as the research shifts orientation. The result of this, he argued, was that this often created a huge amount of information, thereby making it difficult to limit the scope and boundaries of the study.

Neuman (2000) stated that qualitative research puts a greater deal of trust in the personal integrity of individual researchers. However, it includes a variety of checks on how any evidence is gathered. The measuring of something in more than one way enables researchers to view multiple aspects of it. Trochim (2002b) also stated that there is no single way in which a case study is conducted. A combination of methods may be employed, such as semi-structured interviews and direct observations and these can increase the expressiveness of the data gathered (Flick, 2002, Trochim, 2002b). Brannen (2004) pointed out the varied aims and question posed by many research investigations, saying that they are unable to be addressed by a single research approach or strategy. Patton (1999)

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viewed that an advantage of this method is consistency in overall patterns of data from diverse sources and realistic explanations for differences in data from differing sources. These offer a significant contribution to the overall credibility of the findings.

According to Neuman (2000), the opportunity for biased, dishonest, or unethical research is present in all research. Fairness was thought to be a quality of balance; that is, all stakeholder views, perspectives, claims, concerns, and voices should be apparent in the text.

Guba and Lincoln (1989) proposed two ways of achieving freedom from the contamination of bias in a qualitative study involve inter subjective agreement, or the utilisation of a methodology and a set of methods that are thought to render the study impervious to human bias or distortion. An important check on selective perception and blind interpretive bias can be achieved by having two or more researchers independently analyse the same qualitative data and then compare their findings. By having the participants described in the data analysis react to what is being described, researchers and evaluators are able to learn a great deal about the accuracy, fairness and validity of their data analysis. As Schatzman and Strauss (1973:8) stated, they are “certainly aware of selectivity in human perception and of the probability of bias, but do not view “objective” or “consensually validated” techniques as being free of these limitations either”.

In qualitative research, pattern matching is the crux of any attempt to conduct thematic analyses. Pattern matching implies that patterns of a more complex nature, if matched, give greater validity for the theory, pattern matching convergence and discrimination as a continuum. Concepts are more or less the same, therefore, their interrelations would be more or less convergent or discriminant. This distances the convergent/discriminant distinction from the simplistic dichotomous categorical notion to one that is more suitably post-positivist and whose nature is continuous. The pattern matching correlation reveals, that for our particular study, whether there is a demonstrable alliance between how we theoretically expect our actions will interrelate and how they do in practice. Because pattern matching needs a more specific theoretical pattern

than we typically express, it needs us to point out what our thoughts are regarding the constructs in our studies. Maybe the emphasis on theory articulation in pattern matching would encourage us to exercise more care with the conceptual underpinnings of our empirical work.

## **3.2 Ethics Compliance**

Prior to commencing this research it was necessary to obtain ethics approval from the University of Tasmania Ethics Committee (which is accountable to the Academic Senate of the University of Tasmania and the National Health and Medical Research Council). This is required for any investigation involving humans undertaken within the University of Tasmania.

Ethical approval was necessary as the research falls within the definition of human. In the case of problems arising as a consequence of the research, a mandatory outline of the research's objectives, with contact details, was included in the obligatory information cover sheet before any research commenced. Prior to the conduct of each interview, a consent form and evidence of acknowledgment of working within the Human Ethics Committee guidelines were provided to each participant.

## **3.3 Research Methodology**

The research methodology will be described. It will address the following issues:

- Research strategy; and
- Research procedures.

### **3.3.1 Research Strategy**

As this research is both exploratory and descriptive in nature, a multiple case research strategy is deemed appropriate in order to gain insight into understanding the context of phenomena (Cavage, 1996). The intent of the researcher is to look closely at rich contextual data as much as is possible and avoid the formation of preconceived ideas.

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### 3.3.1.1 Multiple Case Study Approach and Information Gathering

The use of a case study is a broadly accepted research strategy for data collection in the field of IS (Benbasat *et al.*, 1987, Lee, 1989, Orlikowski and Baroudi, 1991, Alavi and Carlson, 1992, Yin, 1993, Markus, 1997). Yin (1994) defined the scope of a case study as an empirical inquiry that looks closely at a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not obvious. Myers (1997) stated that this approach can be applied to IS research, as IS research concerns itself with the organisational context of systems and guidelines for improving the effectiveness of the method have been published. According to Orlikowski and Baroudi (1991), Alavi and Carlson (1992), case study research is the most common qualitative method used for investigation of IS. Benbasat *et al.*, (1987) viewed that a case research strategy is suitable for capturing the knowledge of practitioners and developing theories from it. Hammersley (1992) compared case studies and survey and case studies and experimental approaches, and noted that case study approach has a greater capacity for accuracy than with survey approach. It permits the employment of multiple sources and types of data to gauge the accuracy of major factual claims.

Ellram (1996) suggested three primary qualitative approaches that could be used as part of the case study techniques are direct observation, recordings and interviews. Case study research may involve a positivist, interpretivist or critical epistemology either employing qualitative data collection methods such as interviews, documentation and observations or quantitative data such as questionnaires and time series analysis (Benbasat *et al.*, 1987, Lee, 1989, Yin, 1994, Dubé and Paré, 2003). Shanks (2002) suggested that case study research is able to be used to attain a number of research aims, it can provide descriptions of phenomena, develop theory, and test theory.

Case study research within the positivist tradition is designed and evaluated according to the criteria of the natural science model of research: controlled observations, controlled deductions, replicability, and generalisability. Yin (1994) viewed that how or why questions are used to explore set of events over which the investigator has little or no control. Yin (1994) also stated that case studies that



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attend to the what question are most suitable when the purpose of the study is to explore a new phenomenon. Benbasat *et al.*, (1987) acknowledged that the case study approach allows the researcher to answer how and why questions, which can contribute to a IS researcher understanding the nature and complexity of the processes. Dubé and Paré (2003:607) supported Yin's opinion. They stated that "our findings support this contention. Indeed, what questions were most frequently posed in exploratory case research".

The case study approach is important to IS research because:

- The case research method is very well suited to IS research. This is because the object of study of the discipline is IS in organisations, where interest is shifted to organisational away from issues of a technical nature. More specifically, the application of a case study approach in IS research looks at phenomena in its nature setting, and employs multiple methods of data collection in order to harvest information from one or a few entities, such as people groups or organisations (Benbasat *et al.*, 1987);
- A case study approach allows researcher to keep abreast of rapid changes occurring in the IT world as well as in organisations, and the case research approach has access to and reporting on real-life IT experiences;
- Holistic investigation is a key characteristic of case research, and is well suited to our need to comprehend the complex and ubiquitous nature of interactions among organisations, technologies and people. Richness and flexibility to the overall research process is achieved by the access to, and use of, a wide range of data collection methods, both qualitative and quantitative. This makes case research particularly suitable for the study of a complex phenomenon such as IS (Miles and Huberman, 1994, Merriam, 1998);
- The way to access new ideas and new lines of reasoning, and the ability to pinpoint the opportunities, challenges and issues that are faced by IT specialists and managers is aided by in-depth investigations; and
- Cavage (1996) suggested that case study research is suitable for areas in which existing knowledge is limited. Case study research has often been associated with exploratory research involving description and theory

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development, where it is used to provided evidence for hypothesis generation (Benbasat *et al.*, 1987, Yin, 1994, Cavage, 1996, Shanks, 2002, Dubé and Paré, 2003).

Multiple case studies are widely used in IS research (Benbasat *et al.*, 1987, Shanks, 2002). According to Yin, (1994), Darke *et al.*, (1998), the use of multiple case studies rather than a single case study enables the researcher to view the research phenomenon in different settings. Miles and Huberman (1994:147) stated that “of course, a useful theory should apply to more than one case. The assessment of local causality in this case needs to be tested and deepened through application of the causal explanations to other cases”. They go on to say that “multiple cases are extraordinarily helpful in both generating explanations, and testing them systematically” (Miles and Huberman, 1994:207).

Yin (1994) and Darke *et al.*, (1998) suggested the multiple case study approach is considered more compelling and robust and it allows the cross comparison of, and investigation of multiples sources. Different research perspective requires a range of data collection approaches and analysis methods which produce diverse types of research outcomes (Cavage, 1996). With the claim that evidence from multiple cases, informants or evidence gathering methods has the ability to improve the usefulness of the study for other settings. Yin (1994) identified the replication of multiple cases as the appropriate design when the researcher has the desire to investigate the “general existence of a phenomenon”. If three (or more) cases give similar results, replication has happened (Yin, 1994). In this way, the researcher can be assured that the stability or saturation point has emerged (Glaser and Strauss, 1967, Eisenhardt, 1989, Strauss and Corbin, 1998). Saturation point is reached when further analysis of the data will not reveal additional insights that will contribute to the research (Strauss and Corbin, 1998).

There are no specific guidelines determining what is a suitable amount of cases to use. Eisenhardt (1989) stated that the number of required case studies is dependent upon how much new information is likely to be achieved by the addition of extra cases to the research. The advantage of using multiple case studies is that it may provide literal and theoretical replication Yin (1994) and

opportunities for naturalistic generalisation. According to Benbasat *et al.*, (1987), Darke *et al.*, (1998), the analysis of multiple cases may enable the increase of theoretical replication, whereby some results are similar, and other cases are able to be selected to give contrasting results. Cavage (1996) viewed that other strengths of case study research strategies include being able to study a phenomenon in a natural context and to look closely at a large number of issues and different aspects related to the phenomena.

### 3.3.1.2 Semi-structured: Expert Interviews

Arguably, interviewing is the most widely used method of social research (Fielding, 1993, Seale, 1998). Benbasat *et.*, *al* (1987) pointed out that in general in approximately half of case study research, data were collected by a number of means with the balance relying solely on interviews. The interview involves the asking of questions, listening, expressing interest and recording what was said Neuman (2000). Seale (1998:202) viewed that the “interview is more economical than observational methods since the interviewee can report on a wide range of situations that he or she has observed, so acting as the eyes and ears of the researcher”. Fielding (1993:138) suggested that in interviewing “the questioning should be as open-ended as possible, in order to gain spontaneous information about attitudes and actions, rather than a rehearsed position, and the questioning techniques should encourage respondents to communicate their underlying attitudes, beliefs and values, rather than a glib or easy answer”.

In this research, semi-structured interviewing techniques were adopted. This approach was used because it has the benefit of providing a structure to guide the focus of the interview while allow the specific issues of interest to be pursued. Easterby-Smith *et al.*, (1991) viewed that a semi-structured interview is a suitable method to comprehend the respondent’s opinions and beliefs about a particular situation. Fielding (1993:138) gave a clear picture of semi-structured interviews as:

*“The interviewer asks certain, major questions the same way each time, but is free to alter their sequence and to probe for more information. The interviewer is thus able to adapt the research instrument to the level of*

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*comprehension and articulacy of the respondent and to handle the fact that in responding to a question, people often also provided answers to questions we were going to ask later”.*

The benefit of semi-structured interview is that the viewpoint of a interviewed subject's are more likely to be articulated in a relatively openly designed interview situation than in a standardised interview or a questionnaire (Flick, 2002). Flick added that in the situation where concrete statements about an issue are the goal of the data collection, a semi-structured interview is the more economic way rather than through questionnaires. According to Fielding (1993), validity and reliability of the data and also bias of interviewers are critical criteria that impact upon the quality of interview based data gathering. The main question is whether or not the interviewer manages to restrict and determine the interview and the interviewee to the expertise of interest. While the researcher was aware of the potential problems stated by Meuser and Nagel (1991), in each case the relationships between the interviews and the expert participant was cordial and the interviews were conducted in a climate of mutual respect.

However, in the first round of interviews one participant established only limited rapport with the interviewers. This was not the case in the second interview where a frank and friendly discussion was held that allowed each of the interviewers to freely explore relevant issues. In the other case, English was the participant's second language and, while face-to-face communication was effective, the transcription of the record interviews was difficult, due to lack of clarity of the language and expressions used by the participant. This was partly addressed by having the participant review notes of the interviews. Flick (2002) encouraged the interviewer to articulate in the interview that he or she has some knowledge of the topic being discussed. The term partly standardised interview should be included in semi-structure interview in order to avoid problems.

### **3.3.1.3 Qualitative Analysis**

Research design refers to the attributes related with the design of the study, for example, the nature of research questions, the theoretical bases and the criteria used to select the cases. Myers (1997), Myers and Avison (2002), Jones (2004)

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stated that there has been noteworthy progress in the last 20 years in quantitative and qualitative research in IS. Miles and Huberman (1994), Neuman (2000), Patton (2002) stated that qualitative research is an accepted research approach in the social sciences and for this reason it is appropriate to IS research, because IS as a discipline includes the social setting. Wolcott (2001) viewed that the vital task in qualitative research approach is not to accumulate data, but to eliminate most of the data one accumulates. This requires constant winnowing. The choice of research method impacts upon the mode in which the researcher collects data (Myers and Avison, 2002). Mentzer and Kahn (1995) reported that the use and acceptance of qualitative approach in logistics research has not been widespread. Yin (1994) stated that if deriving an explanation of a phenomenon is a goal, qualitative methods are preferable as they provided depth and richness, which allows researchers to look closely at the how and why questions. While quantitative methods have been employed in many areas, in particular, businesses involved in purchasing and logistics, operations management, marketing and general management, qualitative methods seem to be seen as viable and valuable alternatives (Myers and Avison, 2002).

Myers (1997) and Myers and Avison (2002) stated that qualitative research methods are developed to help the researcher understand people, the social and cultural circumstances in which they live. In other social sciences, such as anthropology, sociology and primary care, qualitative methods have long been the norm. The methods employed by qualitative researchers reflect a common belief that they can provide a more profound comprehension of social phenomena than would be collected from purely quantitative data (Silverman, 2001). According to Benbasat *et al.* (1987), Strauss and Corbin (1990b), Yin (1994), Dubé and Paré (2003), one of the ways of gaining credibility for case study research and qualitative studies is to make the case study research procedures and processes unambiguous, as well as show the detailed description of the research context in order to allow readers to judge the accuracy and suitability of the methodology. There is a need for the unit of analysis in an exploratory case study to be defined clearly, in an effort to enable a definition of boundaries of a theory, and then to define the limitations in the application of the theory. Researchers need to specify the unit of analysis to enable readers to comprehend the manner in which the case

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study relates to a broader body of knowledge. Dubé and Paré (2003) pointed out that exploratory case researchers should continue to define “a priori” constructs so that they are able to make sense of happenings, ensure that there is no overlooking of important issues, and guide their interpretation and focus when they are conducting theory-building research.

In this research qualitative data will be gathered from semi-structured interviews and other sources and be coded to normalise the content for inductive analysis. The research strategy and procedures, data analysis techniques and the approach to the interpretation and discussion of the research program are:

- Independent and dependent variables will be identified from the data. These variables operationalise the *units* or key concepts on which the theory arising from this research will be based (Shanks, 2002);
- Effect-outcome explanatory matrices of cause-effect relationships between the independent and dependent will be developed, grounded in the data to produce viable *laws of interaction* between the *units* identified above (Miles and Huberman, 1984b, 1994, Shanks, 2002);
- Critical analysis of these matrices of relationships will be undertaken to investigate alternative viable explanations of these cause-effect relationships. This may result in multiple contingent matrices being developed to reflect a pluralistic derivation of the relationships present in the data, for example due to conflicting opinions that may be present in the expert interviews; and
- Causal diagrams will be developed that are closely grounded in the data and visually represent the issues and causal relationships between these issues, as raised by the participants.

#### **3.3.1.4 Critical Analysis**

According to Myers (1997) and Myers and Avison (2002), it is the assumption of critical researchers that social reality is historically constituted and that it is produced and reproduced by people. Despite the fact that people can consciously act to change their social and economic circumstances, it is recognised by critical

researchers that their ability to do so is constrained by various forms of social, cultural and political domination.

### **3.3.2 Research Procedure**

The interviewing of participants was the central method for the collection of data (Strauss and Corbin, 1990a, Neuman, 2000). The researcher gathered information via interviews with supply chain manager/RFID experts. The method of analysis employed is pattern matching, deductive reasoning and critical analysis. Yin (1994) stated that pattern matching is a form of empirical testing for qualitative data. A part of this research involved asking the participants to be involved in a series of semi-structured interviews. The participants were selected as they were deemed to be a representative group of potential users of time-temperature monitoring equipment. These were conducted face-to-face with experts in the RFID field and key personnel involved in the perishable foods distribution network, such as fishermen/owners, importers and exporters and service providers who could be affected by the use of the technology.

A major part of these interviews focussed on identifying issues associated with the QA of perishable food and potential outcomes of the adoption of time-temperature monitoring equipment. The researcher coded the interview transcripts to ensure standardised use of terms across all interviews. Based on the information gathered the researcher constructed effect-outcome matrices (at least one for each project) in which she/he described the relationship between the identified issues and the identified outcomes. A comparative study of the results from each of the projects was conducted to determine the extent to which the issues, outcomes and relationships are generalisable across the case studies. The researcher developed independent variables to represent the issues, and dependent variables to represent the outcomes. The cause-effect relationship between the dependent and independent variables was characterised by the researcher using causal diagrams that depicted relationships. The researcher then engaged in participant validation of these results to determine their validity. By conducting multiple case studies this research strategy provided an opportunity for the participants in the research

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to gain an understanding of how best to investigate the value of time-temperature monitoring equipment along perishable food chains.

The aims of the interviews were fivefold:

1. To explore current issues concerning the custody of perishable foods, environmental parameters, and maintenance of cold chains during the delivery cycle;
2. To determine the concerns, expectations, and desired changes of the interviewees using technology for time-temperature monitoring in the supply chains of perishable foods;
3. To identify potential areas for future research in the adoption of time-temperature monitoring equipment in the Australian perishable foods industry;
4. To contribute to the current body of knowledge in relation to the use of time-temperature monitoring equipment in the transportation of perishable foods; and
5. To investigate claims of vendors for time-temperature monitoring equipment.

### **3.3.2.1 The Question Format**

Gillham (2000) recommended that the number of interviews and length of each question in semi-structured interview need to be controlled. The content of the question guide was validated with a series of pilot interviews to ensure that the data received from the interview process was meaningful and as non-ambiguous as possible. An outline of the semi-structured questions is included in Appendix 1. The main purpose of the first round interview was to identify the issues and outcomes of the use of time-temperature monitoring equipment in QA perspectives, and also to explore the participants' experience with time-temperature monitoring equipment with perishable food supply chain. The second round interview explored the accuracy of the first round data analysis summary, in order to be able to develop a preliminary model of benefits of time-temperature equipment.



The questions addressed the following issues:

- ***Section 1: Business Background***

The aim of the first section of questions was to collect background information about the organisation. Questions were framed to determine core product or services the organisation provided, the nature of products, the life cycle of products, the size of the organisation, organisation barriers, the type of business (import or export), target customer (local, national or international markets), the benefits, the quality of product when they arrive to customers, types of transportation, and the duration of delivery.

- ***Section 2: Technology Background***

The questions in the second section focussed specifically on the use of time-temperature monitoring equipment and existing technology. For example, Information Communication Technology (ICT) awareness, issues, challenges problems with existing technology, experience of other technology, technological alternatives, time-temperature monitoring equipment awareness, and expectations of temperature monitoring equipment in terms of accuracy, reliability, efficiency and effectiveness.

- ***Section 3: Impact of Time-temperature Monitoring Equipment***

In these questions participants were asked to explain the impact of temperature monitoring equipment for supply chain participants. Questions were posed on the importance of temperature monitoring equipment to food chain participants and to determine any associated changes in the business processes within the organisation and external to the organisation. For example, “What are the temperature monitoring equipment barriers and what are the legal and social barriers to temperature monitoring equipment?” Further questions were also asked about knowledge or change management in the organisation after implementing temperature monitoring equipment.

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- ***Section 4: Problems Encountered Using Time- temperature Monitoring Equipment***

Section four aimed at identifying problems that may have been encountered adopting and using time-temperature monitoring. For example, problems that may have appeared during the transportation of fresh foods, while conducting temperature monitoring equipment transactions and those associated with air transport. In addition, problems with time-temperature monitoring equipment were explored such as standard, security and privacy concerns, health concerns, frequency and read ranges, reliability, accuracy of time-temperature monitoring equipment, and cost of implementation time-temperature monitoring equipment were raised. The final section included questions that asked participants about the future of implementation of time-temperature monitoring equipment in their food chains.

- ***Section 5: Additional Information Relate to the Research***

The aim of the last section of questions was to collect any further information such as financial reports and annual reports, as well as opportunity for further involvement in this research.

The framework of questions was intended to provide a detailed understanding of the industry and highlight specific issues. Therefore, some questions asked in the interview were upon initial responses gained from the interview guide schedule.

Questions for experts were structured around the following perspectives:

- ***Systems***

Can time-temperature monitoring equipment do what it says it can? Can it be implemented? What are the any technological alternatives? Can we provide effective results for logistics management? If we use cost and benefits analysis technology (cost versus spoil saving) to evaluate this technology, Is it worth implementing?

- **Process**

In implementing any such technology what are the organisational barriers to its use? What has happened in specific cases? What extra cost has been incurred in change management associated with the introduction of this technology?

- **Relationships to Supply Chain Partners**

What are the legal and social barriers to technology utilisation? How might these prevent the implementation of temperature monitoring equipment across national boundaries?

With these perspectives the following topics were addressed:

- The perishable foods industry background;
- The issues, trends and attitudes of the current situation within the industry;
- The supply chain management of their business;
- The current method of food quality management;
- The nature of the economic in logistics of perishable foods;
- The impacts and problems arising from transporting perishable foods;
- The understanding, attitudes, awareness and expectations to temperature-monitoring equipment and others technology;
- The experience with business cases or product trials with time-temperature monitoring equipment technology;
- The benefits of the implementation of time-temperature monitoring equipment; and
- The outcomes that can be attributed to the use of time-temperature monitoring equipment.

### **3.3.2.2 Selection of Potential Participants**

A letter of introduction was mailed to supply chain participants. The letter was addressed to the key personnel involved, such as owners and managers who take responsibility for perishable foods chain. Initially participants were invited to be involved in the research via a letter of introduction, with prospective persons/organisations being contacted electronically or by telephone a few days later. In line with the Ethics Committee of the University of Tasmania's

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guidelines, confidentiality of the published results was assured. To ascertain the willingness of the prospective participants to join in the study and to confirm the receipt of the letters of introduction, the researcher made contact with the relevant personnel. The information sheets and consent forms were sent out to the participant ten days before conducting the interviews. Upon confirmation of their willingness to join in the study, a convenient time for interview was established.

As recommended by Eisenhardt (1989), case selection were selected on the basis of the research interests and conceptual framework. This permits what Glaser and Strauss (1967) call “theoretical sampling”. Taking this principle further Yin (1994) proposed two criteria for selection: cases where similar results are expected for literal replications and cases where contradictory results are predicted to achieve “theoretical” replication. The generalisability of results are thus enhanced and in turn, the validity of the research enhanced.

The selection of the cases was conducted to provide a representative group of supply chain manager and RFID experts that were actively utilising time-temperature monitoring equipment in the perishable food chain. Due to the relatively newness of the technology, there were only a few experts in this area, especially in Australia. This limited the availability of participants to take part in this research. The five cases were selected because they have different characteristics, such as perishable food industries, storage and handling, level of tolerance, and harvest season, as recommended by Eisenhardt (1989). Shanks (2002) stated that select case study sites for multiple case studies should be justified by the use of literal or theoretical replication. This meant the questions had to be relevant to each case.

The main criteria for the selection process were based on four key requirements:

1. The organisation needed to be classified as part of the perishable food industry;
2. The organisation had to have been involved with time-temperature monitoring equipment or comparative technologies within their cold chain distribution;

3. The organisation had to have an understanding of the importance of quality assurance through environmental monitoring in their cold chain distribution; and
4. The duration, temperature, humidity and improvement survival rate of products of each cold chain needed to be critical factors.

### ***Organisations Involved in the Case Study***

The participant organisations were located in Tasmania, Sydney and Melbourne. The organisations involved in this research were representative of perishable food chains, technology service providers, food processors, and experts in time-temperature monitoring equipment in Australia. Eisenhardt (1989) suggested that the number of case studies should be between four and ten. If there are fewer than four cases, theory is difficult to generate whereas if there are more than ten cases, the volume of data is difficult to cope with. A total of fourteen companies were chosen to do the first round data collection. Tables 3-3 presents an overview of the characteristics for each case in relation to the number of interviewees, type of business, positional role of the participant (s) and location where interview was conducted. These were selected because they have different characteristics from each other, as (Eisenhardt, 1989) recommends. They have dissimilar existing business models and supply chain management, levels of time-temperature monitoring equipment experience as well as capacity for developing the technology.

### ***Location of the Study***

The interviews were held in Tasmania, Sydney and Melbourne, and involved both rural and urban areas. Tasmania was selected as suitable research locations due the high proportion of export of live perishable foods (fish, crustaceans and mollusks) in comparison with other states of Australia. Most of Tasmanian seafood products are transported to South East Asia by air in order to maintain freshness and quality of products. Tasmania is an island state separate from the mainland states, therefore products have to be transported via Sydney or Melbourne when exporting to overseas. As a result of this, logistics costs, time and quality are critical factors to be considered by food processors and exporters in Tasmania.

Melbourne was chosen as a transportation hub for sea and air freights from Tasmania to overseas. Some products need to be repackaged in Melbourne in order to extend their shelf life. Also, one of the largest importers of live aquaculture products from Tasmania is located in Melbourne.

A manufacturing company with distribution chains throughout Australia and South East Asia was chosen to participant in the research project. A food science research organisation and an associated research and development company were combined into a single case study, partly because they had a focus on the export of red meat products. These participants are located in the Sydney region.

**Table 3-3. Characteristics of First Interview Cases**

Case	Number of Interviewees	Type of Business	Position	Location
C1	1	Aquaculture	Production and Logistic Manager	Tasmania
C2	1	Technology service provider	Chief Executive Officer	Sydney
C3	1	Technology service provider	Manager- Global Business Development	Melbourne
C4	1	Freight logistics council	Chief Executive Officer	Tasmania
C5	1	Confectionary	Product Quality and Third Party Coordinator	Sydney
C6	1	Perishable	Logistics Manager	Tasmania
C7	1	Dairy	Logistics Manager	Melbourne
C8	1	Food safety research	Food Safety Expert	Sydney
C9	1	Aquaculture	Director	Tasmania
C10	1	Technology service provider	Managing Director	Melbourne
C11	2	Confectionary	Materials Maintenance Manager and Quality & Environmental Manager	Tasmania
C12	3	Food safety research	Co-director & Science Program Manager	Tasmania
C13	2	Aquaculture	General Manager and Factory Manager	Tasmania
C14	1	Aquaculture	Director	Melbourne

Five cases were chosen as the second round interviews. The reasons for excluding the nine companies are shown in Table 3-4.

**Table 3-4. Reasons for Eliminating Nine Cases from the First to Second Round Interviews**

Case	Type of Business	Reasons for Non-selection
C2	Technology service provider	<ul style="list-style-type: none"> <li>• Nature of business activities</li> </ul>
C6	Perishable	<ul style="list-style-type: none"> <li>• Lack of knowledge and understanding of the technology</li> <li>• Lack of financial resources</li> <li>• Nature of business activities</li> <li>• Lack of technology skills and experience</li> </ul>
C7	Dairy	<ul style="list-style-type: none"> <li>• Lack of knowledge and understanding of the technology</li> <li>• Lack of financial support</li> <li>• Nature of business activities</li> <li>• Lack of technology skills and experience</li> <li>• Lack of other organisational resources</li> </ul>
C10	Technology service provider	<ul style="list-style-type: none"> <li>• Nature of business activities</li> </ul>
C9	Aquaculture	<ul style="list-style-type: none"> <li>• Nature of business activities</li> <li>• Lack of technology skills and experience</li> <li>• Lack of financial resources</li> <li>• Lack of other organisational resources</li> </ul>
C3	Technology service provider	<ul style="list-style-type: none"> <li>• Nature of business activities</li> </ul>
C11	Confectionary	<ul style="list-style-type: none"> <li>• Lack of financial resources</li> <li>• Lack of knowledge and understanding of the technology</li> </ul>
C4	Freight logistics council	<ul style="list-style-type: none"> <li>• Lack of financial resources</li> <li>• Nature of business activities</li> </ul>
C12	Food safety research	<ul style="list-style-type: none"> <li>• Lack of financial resources</li> </ul>

Table 3-5 describes the five case studies that were progressed to a second round interview. For the purposes of this research they have been renamed alphabetically A-E.

**Table 3-5. Characteristics of the Cases Selected: Second Interview**

Case	Number of Interviewee	Type of Business	Position	Location
C1 (A)	1	Aquaculture	Production and Logistics Manager	Tasmania
C13 (B)	2	Aquaculture	General Manager and Factory Manager	Tasmania
C14 (C)	1	Aquaculture	Director	Melbourne
C8 (D)	1	Food safety research	Food Safety Expert	Sydney
C5 (E)	1	Confectionary	Product Quality and Third Party Coordinator	Sydney

### 3.3.2.3 Data Collection

Benbasat *et al.*, (1987) stated that the case study methods should employ an array of methods for data collections in an effort to gather quality data for the issues being investigated. This involves the choice of data collection methods (both qualitative and quantitative) and the way in which these are applied, along with the strategies used for enhancing the reliability and the validity of the data gathered (Dubé and Paré, 2003). Case study research gives the opportunity to employ many different sources of evidence. Benbasat *et al.*, (1987) stated that a clear description of the data sources and the manner in which they add to the findings of the research is an important part of the reliability and validity of the findings.

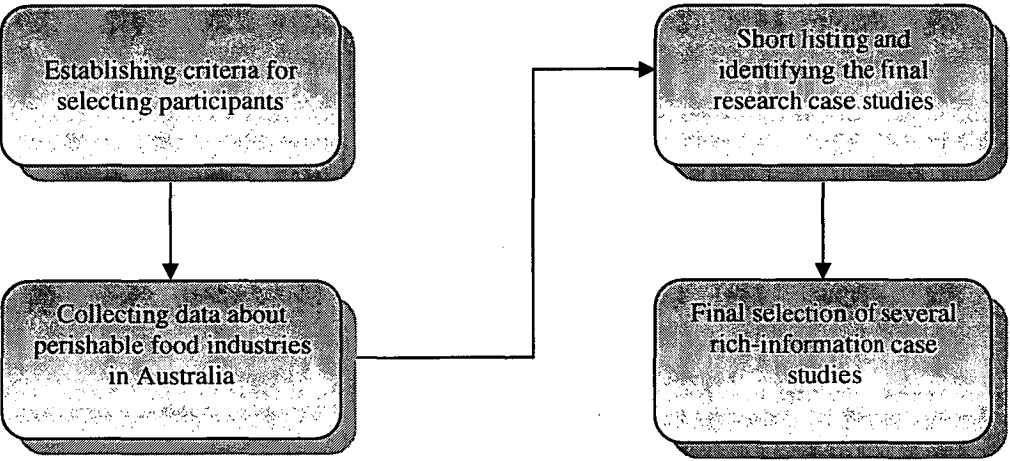
The pilot studies created a building block to support the subsequent investigation into the industry. The first round of interviews afforded context and background to the industry. It also emphasised crucial issues that had direct implications on the present situation within the industry. Company documents (such as newsletters and press announcements), and archival records (such as financial reports) were used rigorously in an effort to maximise the coherence of the gathered information. Public newspapers, the company websites and periodicals provided extra information. By having multiple data sources, it was possible to achieve cross-checking of data which is a vital factor in interpreting phenomena and deriving findings.

During the second round of interviews, the following were studied: the confirmation of the accuracy of the first round interview, further information

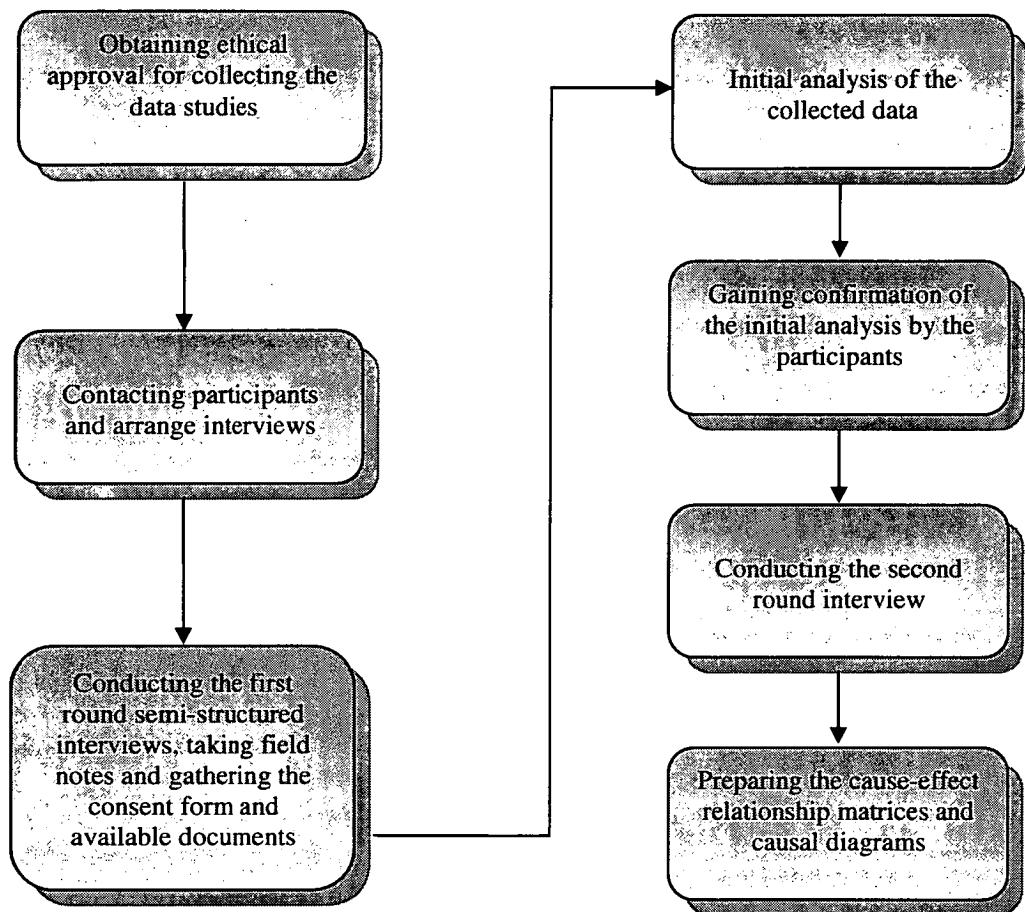


based upon the participants since the first interview on factors affecting benefits on time-temperature monitoring equipment and further member checks (Guba and Lincoln, 1981).

The process of data collection was conducted in June-July 2005 and December-January 2006. The researcher was interested in following the progress from participants between the first and second round interview as some of the participants have implemented some trials of time-temperature monitoring around the time of the first round interviews. The process concerning the theoretical selection of case studies is illustrated in Figure 3-1. The details of data collection procedures are shown in Figure 3-2.



**Figure 3-1. The Selection Process of Case Studies**  
Source: an adaptation from (Qur'an, 2005)



**Figure 3-2. The Procedures for Collecting Data from Case Studies**

Source: an adaptation from (Qur'an, 2005)

### ***Pilot Case Study***

One pilot study was conducted to test the design of the questions format and refine the data collection instruments in order to test the validity and reliability of the questions and ensure that the questions were clear (Fielding, 1993, Yin, 1994, Flick, 2002).

An organisation in Tasmania agreed to participate in the research as the pilot case. The Production and Logistics Manager was contacted and given the aim and objectives of the research. The pilot study refined the proposed set of semi-structured questions into a standardised set for use with other case study participants. As a result of the pilot study it was decided to provide a better understanding of the use of time-temperature monitoring from a QA perspective. After conducting the pilot case, feedback was obtained pertaining to the nature of

the questions asked, so as to help the researcher to further refine the questions. A few of the questions had to be modified for easier understanding.

#### **3.3.2.4 The Interviews & Transcripts**

The interview process started with the researcher providing information about the research aims and objectives and the background of time-temperature monitoring equipment, as defined in Section 2.3. The interview process was conducted face-to-face and the participants were asked to answer the questions. During the interview, a portable digital recorder was used as it is an essential part of the canonical practice of conversation analysis (Hussey and Hussey, 1997, Neuman, 2000, Have, 2004, Perakyla, 2004). The digital recorder was also used as it allowed the researcher to focus on the interviews, rather than spending time writing field notes. This can prove a distraction Neuman (2000) stated that recorders provided a close approximation to what occurred and a permanent record that others can review. It helps a researcher recall events and observe what does not happen, or non-responses, which are easy to miss at the time of the interview. Important issues, such as the conclusion of each interview and the personal comments/thoughts about the interview were also revealed as transcript notes. The duration of each interview was about an hour.

The researcher checked the major points at the conclusion of each interview in order to avoid misinterpretation. Transcription of the digital recording was done as soon as possible after the completion of each interview, complying with what is referred to as the 24 hours rule (Yin, 1989), which ensures that the interview is transcribed while the interview is still fresh in the mind of the researcher. Any ambiguities were clarified by the interviewer contacting the interviewees at a later date. The first round interviews were transcribed verbatim and analysed before the second round interview took place. The data analyses of the first round interview were sent to all participants before the second round interviews were conducted. This approach was adopted to confirm the accuracy of the data analysis.

There was only one case study where some minor changes during conduct of the research was identified. This participant added an explanation to a comment in one of his interview transcript analysis and asked that a sentence describing a

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particular achievement be removed from the analysis as he felt it was a risk to his technology service provider.

### 3.3.2.5 Data Coding

Tesch (1990) viewed that there is not one “right way” to analyse data in a qualitative approach. However typically it involves a process of developing code and categories and making iterative and subjective comparisons and contrasts of the data. The aim of data analysis is to find meaning in the information collected (Minichiello *et al.*, 1990). “Analysing data is the heart of building theory from case studies, but it is both the most difficult and the least codified part of the process” (Eisenhardt, 1989:539). As such, it is important to first assess the extent to which case study researchers have elucidated the data analysis procedures. Clear descriptions of the analytic approach used allow the reader to better understand the findings and judge the extent to which they are the results of a systematic and rigorous process (Dubé and Paré, 2003). Stake (1995) pointed out that the aim of qualitative data analysis was to communicate an understanding of data collection methods, such as semi-structured interviews. Merriam (1998) indicated that semi-structured interviews can be problematic because of the large volume of information and data collected, which makes analysis complex, difficult and often contradictory. Coding is a method of classifying data into various categories, using terms, phrases, codes or themes that capture relevant characteristics of the data. It is a standard process for breaking data into smaller units of analysis and using categories to reduce the data quantity and to move the data elements to a higher level of abstraction (Coffey and Atkinson, 1996).

Marshall and Rossman (1995) viewed that data collection and analysis must be a simultaneous process in a qualitative research design. Miles and Huberman (1994) described data analysis as consisting of three activities, which occur concurrently and involve data reduction, data display, and conclusion drawing and verification (Miles and Huberman, 1984b, Miles and Huberman, 1984a, Miles and Huberman, 1994).

Data reduction refers to the process of selecting, focusing, simplifying, abstracting, and transforming the raw case data. The process of data reduction in

this research began as soon as the important topics or themes were identified and continued throughout data collection and thesis writing.

Data display refers to the organised assembly of information that permits the drawing of conclusions where verification involves extracting meaning from data and building a logical chain of evidence.

Data reduction, data display and conclusion drawing and verification were activities of data analysis occurring interactively throughout the research. It can occur through the selection of a conceptual framework and is achieved via writing summaries, coding, teasing out themes, making clusters, making partitions and writing memos (Miles and Huberman, 1994).

The data needed to be in a format that was organised to accommodate a flexible method for meaningful data component retrieval. Data coding provided a structured and controlled procedure to facilitate this. Categories were formulated by linking common themes. The concept of these categories could be related to one another and so are classified as emerging themes (Strauss and Corbin, 1990a).

The aim of qualitative data analysis was the task of discovering themes (Ryan and Bernard, 2005). By themes, Ryan and Bernard (2005:1) mean “abstract, often fuzzy, constructs, which investigators identify before, during, and after data collection”. The assortment of codes, concepts and themes were closely related to one another and are grounded in the data.

Drawing on the principles of critical analysis and pattern matching, this analysis combined two qualitative data analysis techniques. In presenting the analysis this section also describes how five case studies are used to exemplify the procedures employed in this combined approach. “Formats can be as various as the imagination of the analyst, but they usually turn out as a summarising table (matrix, chart, checklist) or figure” Miles and Huberman (1984a:79).

An effect-outcome matrix displays on one or more outcomes, in as differentiated a form as the research requires. Miles and Huberman (1994) stated that they

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consider qualitative analysis to be a very powerful method for assessing causality. With its close-up study, qualitative analysis can identify mechanisms beyond sheer association. It is locally focussed, and deals well with complex networks of events and processes in a situation. It is well equipped to cycle back and forth between variables and processes – showing that “stories” are not unreliable, and include underlying variables that are not intangible, but have associations over time. Examples of data coding techniques will be provided in Chapter 4.

### ***The Coding Process: Open Coding***

The coding paradigm originally articulated by Strauss (1987) and further refined by Strauss and Corbin (1990b) was applied: “coding represents the operations by which data are broken down, conceptualised, and put back together in new ways” (Strauss and Corbin, 1990a:57). The collection and analysis of data were done simultaneously (Strauss and Corbin, 1998). Data analysis was undertaken using the process of open coding and axial coding techniques. Three types of coding are proffered involved open coding, axial coding and selective coding. The open coding procedure involves the development of concepts and themes emerged in the data. Open coding allowed similar incidents and phenomena to be compared and contrasted with each other, and where similar were correspondingly coded (Neuman, 2000, Douglas, 2003).

Strauss and Corbin (1990b:69) stated that “the process of open coding stimulates the discovery not only of categories but also of their properties and dimensions”. According to Strauss and Corbin (1990b:62):

*“Open coding is the part of analysis that pertains specifically to the naming and categorising of phenomena through close examination of data. Without this first basic analytical step, the rest of the analysis and communication that follows could not take place. During open coding the data are broken down into discrete parts, closely examined, compared for similarities and differences, and questions are asked about the phenomena as reflected in the data”.*

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Using an open coding approach, data were initially reviewed line by line to enable close examination, interpretation, and categorisation of information (Glaser, 1978). During open coding, the transcript of each interview was reviewed multiple times and the data reduced to codes and then the codes were grouped in categories in order to arrange them into the cause and effect matrices. Codes and categories from each interview were compared with codes and categories from other interviews for common and disparate themes.

### ***Axial Coding***

The axial coding stage was used to organise and expand the theoretical framework inherent in the research by identifying linkages within the categories and between the categories (Neuman, 2000). Core codes are aggregates of closely interrelated open codes that have strong supporting evidence (Strauss, 1987, Strauss and Corbin, 1990a). Axial coding was used to explore the relevance and appropriateness of the initial set of open codes (Strauss and Corbin, 1998). Axial coding was concentrated on the conditions and situations which cause a phenomenon to take place and the strategies applied to control the phenomenon (Strauss and Corbin, 1990b). This process allowed links to be made between categories, and then selective coding developed the main categories and their interrelationships. The data was used to define the main themes and a model generated to show the relationships among themes.

### ***Selective Coding***

Selective coding is “the process of selecting the central or core category, systematically relating it to other categories, validating those relationships, and filling in categories that need further refinement and development” (Strauss and Corbin, 1990b:116). The core category is “the central phenomenon around which all the other categories are related” (Strauss and Corbin, 1990b:116). Selective coding requires the selection of the focal core code; that is, the central phenomenon that has emerged from the axial coding process.

All other codes derived from axial coding must in some way be related to the focal core code, either directly or indirectly. These codes can be classified as representing context, conditions, actions, interactions and outcomes. Thus a

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theoretical framework of interrelated concepts can be developed, and a postulates developed regarding the relationships between the central concept and the phenomena identified in the responses to the questions.

### 3.4 Data Analysis

The data were analysed based on Miles and Huberman (1984, 1994). This involved identifying independent and dependent variables and constructing cause and effect matrices that were presented as a series of three, within case analysis matrices. These were *Change Matrix*, *Effects Matrix: Direct, Meta, and Side Effects* and *Explanatory Effects Matrix*. The data were then used to develop causal diagrams. The final analysis involved the construction of between case tables, based on the key themes that emerged from the cause and effect tables. Visualisation and interpretation is an important part of the methodology. These processes of data analysis and the consequent findings will be presented in detail in Chapters 4 and 5.

### 3.5 Summary Reflections

This chapter outlined the philosophical position adopted by the research. An objective ontology utilising post-positivist epistemology was deemed the most appropriate for the exploratory nature of the research. Details of how the study would address the issues of validity, reliability and trustworthiness of the research were then presented. Eight validity approaches which are appropriate to qualitative research were explored. The multiple case-study method was adopted as it was seen as the most suitable. This approach was support because the research was comparative in nature, where realities are constructed in relation to contextual elements. The use of multiple case studies enabled a rich insight into the experiences, views, attitude and meanings participants associated to the use of time-temperature monitoring.

The research design and methods used to collect the data from multiple cases was then described in some detail. A series of interviews were conducted with owners, managers and people who take responsibility for perishable food in cold chain distribution. The participants covered red meat, seafood, vegetables, dairy and



confectionary food. The question frame was designed to gather background information from the participants about their business, the impact and problems/issues associated with the use of time-temperature monitoring with QA perspective, opinions, and experiences of existing transport technology and the understanding of time-temperature monitoring equipment within cold chain management.

The chapter then developed an approach to data analysis within the multiple case studies. Figure 3-3 summaries the research methodology adopted in this research. As shown in Figure 3-3 a summary of the research methodology is composed of a series of six key issues that represent the stages of the theory building process used for this research. Each one in turn guided the decisions and approaches taken in the research methodology. For example, the research purpose established that the research would be exploratory in nature. This choice is supported by the literature which identified there was a lack of research evidence on the topic. The research approach utilised an objective ontology in conjunction with a post-positivist epistemology employing critical analysis.

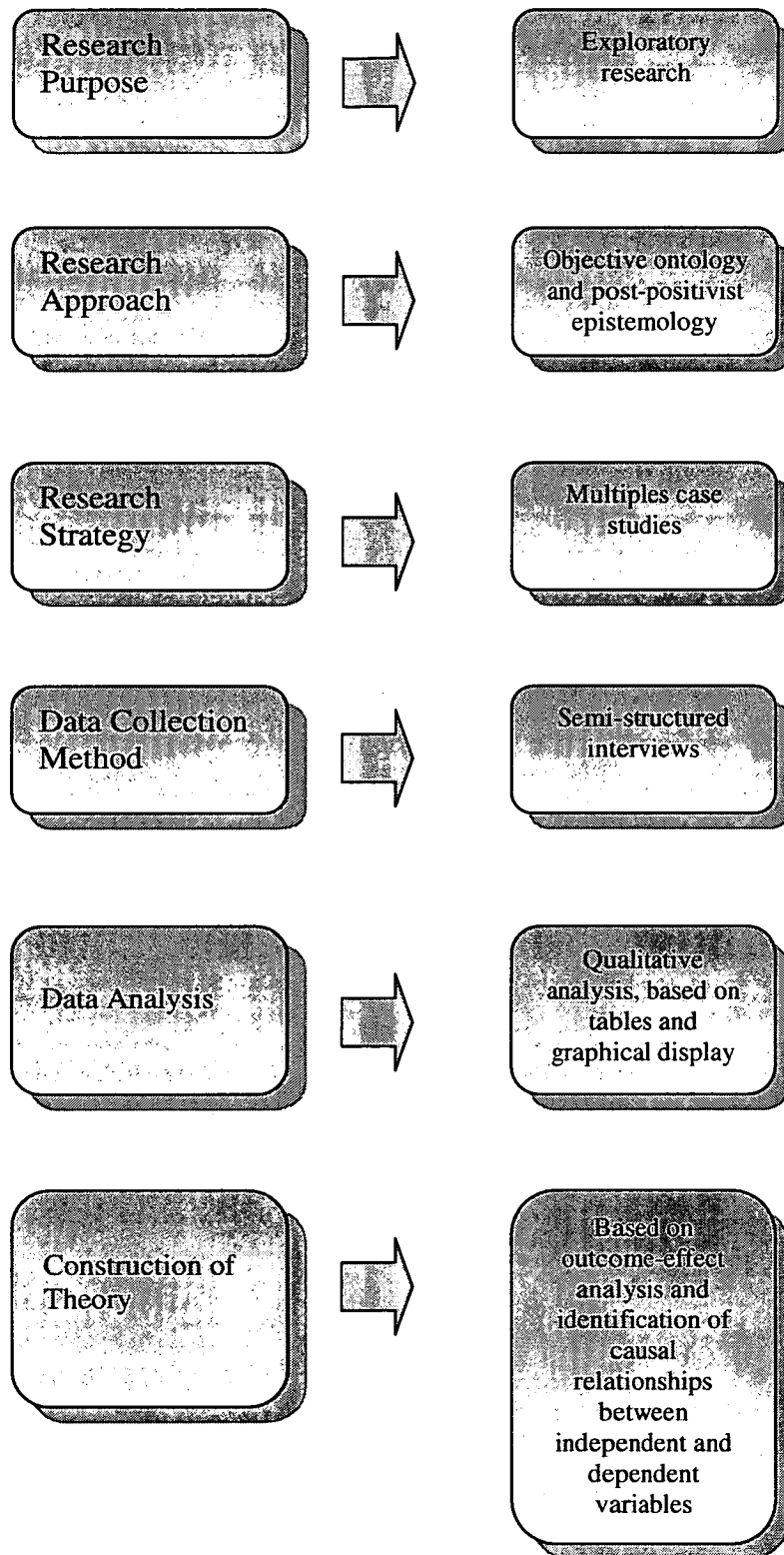
The researcher used an objective ontology because she seeks to provide a description of the cause and effect model, more specifically, aiming to be able to give a quality empirical explanation of the social scientific process. The researcher also seeks to establish procedures and criteria that can support commonly adjudicated truth claims from participants that do not depend solely on those subjectively experienced or believed realities. This was sensible because time-temperature monitoring technology (RFID technology) is not well developed as the phenomena are dynamic, relatively new and have had relatively little application in the perishable food industry. In addition, most of the published research focuses on the use of passive RFID in retail business rather than the use of active RFID for time-temperature monitoring in the perishable food industry. This is evident in the literature on active RFID in logistics where terminology is not yet clear or widely developed. Therefore, the researcher had to use existing theory to form a model, identifying ROI as a critical factor to implement the technology, against the literature review/case studies.

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Post-positivist was used due to the lack of established theory in this area and the limited sources of data, especially a lack of quantitative data available because so few companies have actually implemented the technology, therefore, the researcher needs to rely on the material gathered from the participants through case studies. Rapport building with participants was critical to the effectiveness of the information gathering, so that participants would be forthcoming in providing rich information. While, the researcher is striving for correctness and completeness in the gathering and analysis of the data, it is recognised that the knowledge of participants and the analysis techniques are imperfect and cannot produce an absolutely correct model of the impact of the adoption of the technology. The adoption of a critical analysis approach allows the researcher to accept that some things are tangible, measurable and knowledge, and other things are intangible, may not be measurable and knowable in detail. This decision is supported by the aim of this research being to gain deep insight into the issues and factors surrounding the technology and to gather the views and opinions of participants regarding their technology adoption.

The research strategy involved a qualitative research approach using multiple case studies and the data collection involved using semi-structured interviews with logistics and quality assurance managers/owners. The intention of the researcher is to look closely at a wide cross section of business in order to provide rich contextual data and to avoid the formation of preconceived ideas. The analysis techniques were based on domain analysis deploying tables and graphical displays as described in Miles and Huberman (1984, 1994). This choice is supported by seeking to characterise and explain the nature of the semantic relationships present in the data. These displays had the advantage of showing all the relevant responses from each participant on individual sheets, that later enabled comparisons between the responses from all participants. Furthermore, this technique also assists in the formulation of descriptions by breaking the codes derived from the data into entries in the tables. The rigorous analysis of the data required in order to meaningfully populate these tables enabled the researcher to uncover many aspects of the data that were not immediately evident from reading and listening to the transcripts. The construction of the theoretical framework was based on outcome-effect analysis and the identification of causal relationships

between independent (issues) and dependent (outcomes) variables. This choice is supported by assisting in the derivation of interpretations and critical analysis of viable explanations.



**Figure 3-3. A Summary of the Research Methodology**

## CHAPTER FOUR: DATA ANALYSIS

### 4.0 Introduction

This chapter provides a detailed explanation of the analysis of the data collected within this research. As described in Chapter 3, data were collected through conducting multiple semi-structured interviews. Immediately following each interview session, the recordings were transcribed to facilitate data analysis. Coding and qualitative analysis techniques were used to reveal underlying concepts and themes embedded within the data.

In summary, the process used to analyse the data involved an effect-outcome analysis method, based on Miles and Huberman (1984, 1994). Within this, the data were analysed and interpreted on an individual case basic, through the use of a series of matrices: *Change Matrix*, *Effects Matrix: Direct, Meta and Side Effects*, as well as *Explanatory Effects Matrix*. Causal diagrams were used to identify the input factors and response variables and the nature of their relationships. This analysis was carefully grounded in the data obtained in the case study interviews. Following this a cross-case analysis was performed.

Broadly this chapter provides the following aspects of the analyses:

- A profile of the participant organisations;
- Approach taken to qualitative analysis;
- A demonstration of this approach; and
- Summary of reflections.

### 4.1 A Profile of the Participant Organisations

In this research the transcripts from the five case studies were analysed to interpret experiences related to the adoption of time-temperature monitoring equipment and how they can be employed to quality assure state of perishable foods in cold chain distribution. Examples from the analysis of the five case studies are presented to illustrate the qualitative data analysis processes used with each case study.

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### **4.1.1 Analysis of Five Case Studies**

The case studies sought to analyse the benefits of the use of time-temperature monitoring equipment for cold chain monitoring in order to quality assure perishable food products during transport. The information from the five case studies was gathered through semi-structured interviews. Additional, secondary information was sourced from the Internet, published papers and financial reports.

**The interview for Organisation A** was conducted within an organisation in rural Tasmania. It is an Australian owned producer and exporter of aquaculture products. The interview was conducted on 28<sup>th</sup> July 2005 at 9:00 a.m. and was approximately 50 minutes in duration. The participant in the interview was the Production and Logistics Manager. The session was conducted by the researcher, with the chief investigator in attendance. The participant in this study had taken part in the initial trial implementation of active RFID technology for time-temperature monitoring, and was building a business case for its adoption by the organisation. As such he was very knowledgeable in the area that is the focus of this current research. The understanding of the participant of active RFID technology was from a logistics and quality assurance perspective. Since the participant was not directly involved in the strategic decision-making, the initial adoption of active RFID technology was beyond his control.

Organisation A has been trading for over 10 years and has a major market share of the Australian aquaculture industry. The organisation specialises in the production and processing of aquaculture products. These include both raw and smoked salmon, as well as salmon caviar. The products are packed in cardboard containers that are stored in a chilled environment before they are shipped via air and sea freight. The organisation produces approximately 4,500 tonnes of goods each year, with around 1,500 tonnes being exported to Asia Pacific areas outside of Australia.

The organisation operates under a number of internal and external standards, but the primary one is the export control of meat, eggs and fish products, including the Australian Quarantine Inspection Service (AQIS) requirement (DAFF, 2006),

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SGS International Certification Services (SGS, 2006) and ISO 9002 requirements (ISO, 2006). The cold chain guideline standard definition applies to chilled products, that must be maintained in an environment of between -1° and 4° during transportation (AFGC, 1999). The maintenance of temperature is a prime concern in the quality control of the products. The ultimate goal of the supply chain of Organisation A is to add value and manage risk for customers. The supply chain of this organisation starts when fish are harvested in 1,000 litre bins. These are then processed, chilled, packed and sent to receivers. Active RFID monitoring has been used during processing, when tags have been placed inside the gutted fish and data loggers are strapped on the outside to detect the internal (core) and external temperatures. The organisation has also placed another tag on the outside of shipping containers in order to monitor time-temperature.

**The interview for Organisation B** participant was conducted in his office in Hobart. The first round interview was held on the 28<sup>th</sup> July 2005, at 3:00 p.m. and took approximately 44 minutes, with the General Manager. A follow-up interview was held on the 9<sup>th</sup> January 2006 at 10:00 a.m. at the organisation's factory. That interview took approximately 1:30 hours. In this interview the participants were the General Manager and the Factory Manager. The interviews were conducted by the researcher, with the chief investigator in attendance.

Organisation B is a company which processes shellfish products in Tasmania. It was established over 5 years ago and operates throughout the year. The organisation has grown rapidly to incorporate interstate and overseas partners. It processes a significant share of the shellfish products produced in Tasmania, that amount to more than one million dozen shellfish each year. The organisation focuses on a high quality niche shellfish market. This organisation distributes a range of shellfish to local, national and international markets. The organisation operates through the Australian Quarantine Inspection Service (AQIS) (DAFF, 2006) and complies with Hazard Analysis and Critical Control Point (HACCP) (FSANZ, 2005a). While quality is assured for the shellfish when in the cold store rooms of the processor, this is not the case once they leave this storage facility. After this point in the supply chain the temperature of the shellfish is not monitored.

Table 4-1 sets out the different processes shellfish production for live, fresh and export market which should be kept between 2 to 4 degrees during transport.

**Table 4-1. The Process of Shellfish Production**

Live Shipment	Fresh Market	Export Market
<ul style="list-style-type: none"> <li>Washed by hand</li> </ul>	<ul style="list-style-type: none"> <li>Chilled in a refrigerated store</li> </ul>	<ul style="list-style-type: none"> <li>Quick frozen by passing through a liquid nitrogen tunnel</li> </ul>
<ul style="list-style-type: none"> <li>Packed into polyester boxes</li> </ul>	<ul style="list-style-type: none"> <li>Packed into cardboard boxes</li> </ul>	<ul style="list-style-type: none"> <li>Packed into cardboard boxes</li> </ul>
<ul style="list-style-type: none"> <li>Shipped by road freight to customers</li> </ul>	<ul style="list-style-type: none"> <li>Shipped by road freight as chilled products to the customers</li> </ul>	<ul style="list-style-type: none"> <li>Shipped by sea freight as frozen product in refrigerated containers to the customers</li> </ul>

The entire supply chain of the shellfish is:

- The shellfish are harvested at a range of sea temperatures at aquaculture farms;
- The shellfish are collected into hessian bags at the farms;
- Sometimes the bags are stored in chillers on the farms at 4 degrees, if they need to be held for a day or more;
- The bags are loaded onto trucks which may or may not be chilled;
- The trucks carry the bags from the farms to the processing factories. This can take from 30 minutes to overnight. The processing cycle of shellfish consists of:
  - Washing the shellfish in order to get rid of mud and grit;
  - Cutting half the shell from each of the shellfish;
  - Packing the shellfish cut side down to retain moisture; and
  - Placing the shellfish in polyester boxes with chillier pads, so that they can retain sufficient moisture.
- At the factory the shellfish are held in chillers for one to four days. Longer storage of chilled shellfish for export can help to purge them;
- Most shellfish are cross-docked via a refrigerated cold storage facility in Hobart: and



- Shellfish are transported via trucks to a ferry, then to delivery points on the Australian mainland over a period of up to five days.

The receivers can store the shellfish for up to a week before delivering them to retailers and restaurants. Therefore, the total process of transporting shellfish can take up to 14 days. The supply chain for shellfish is relatively long, and risks can be associated with carriers and distributors who do not handle or store the shellfish properly. For this reason, the organisation would like to monitor the cold chain consignment across the entire distribution chain.

**The Organisation C** interview was conducted at a pre-arranged location in the business area of Melbourne. The interview was held on the 20<sup>th</sup> September 2005, at 11:00 a.m. and took approximately 23 minutes. A follow up interview was held on the 7<sup>th</sup> December 2005 at 9:30 a.m. and took approximately 1 hour. In both interviews the participant was the Managing Director of the organisation. The interviews were conducted by the researcher, with the chief investigator in attendance.

When conducting the interview with Organisation C the researcher was able to understand the interview participant's meaning, even though English was his second language. However, in the transcription the meaning was not always clear. This created problems at the coding stage because the unit of analysis is the sentence.

Organisation C is a well established business and is considered to be the major independent operator in the seafood export industry. The majority of products are rock lobster and abalone. The company sources seafood from Tasmania, Victoria, South Australia and Western Australia. The market for the products is mainly South East Asia. The official season for catching male rock lobsters in Tasmania lasts from 1 November to 31 August, and the season for female rock lobsters from 1 November to 31 April each year. The organisation has problems with the quality of rock lobsters during summer periods when up to 15 percent of rock lobster do not survive live export. The organisation has not had any experience with any time-temperature monitoring equipment.

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The supply chain of rock lobsters begins when the rock lobsters are caught offshore, for example off the North East Coast of Tasmania. They are kept in plastic holding tanks, with oxygen supplied. Stress on rock lobsters can decrease the quality of rock lobsters, as they can lose legs and antennae. Rock lobsters that have been stressed by handling or processing can recover by being held in tanks with good water quality. When ready for shipment, they are placed in polystyrene containers, packed into three layers and covered with chilled wooden shavings. On top of each layer a dampened woven paper sheet is placed to retain moisture. The top layer is covered by 1-1.5 kilograms of ice. The rock lobsters are then transported via air freight to distribution points in South East Asia.

The supply chain of abalone is similar for rock lobster, but abalone need more time to recover from harvesting in the holding tanks, normally four days, before they are shipped to overseas markets.

**The Organisation D** interview was conducted within an organisation in a suburb of Sydney. It was held on the 21<sup>st</sup> September 2005, at 9:30 a.m. and took approximately 27 minutes. The second round interview was held on the 6<sup>th</sup> December 2005 at 1:30 p.m. and took approximately 55 minutes. In both interviews the participant was a Food Safety Expert. The interview was conducted by the researcher with the chief investigator in attendance.

Organisation D represents a food safety science research organisation in Australia. The organisation has branch offices in Sydney, Melbourne, Adelaide and Brisbane. Organisation D is working with a private development company ('Organisation PDC') to determine the relationships between the temperature of processing or cooling and handling, and the quality of the final product. Their products and services are involved with perishable food industries in Australia. Organisation D relies heavily on 'Organisation PDC' to monitor the time-temperature of their products all along the distribution cold chain. 'Organisation PDC' also relies on Organisation D as a research gateway to launch their products. 'Organisation PDC' provides a range of wireless technologies such as Nano-Corn Node tags with General Packet Radio Service (GPRS) and Code-Division Multiple Access (CDMA) facilities.

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Organisation D has also been involved with an active RFID technology supply company ('Organisation RFIDS'). 'Organisation PDC' and 'Organisation RFIDS' have participated in a series of trials of wireless technology solutions for Organisation D. The purpose of the trials was to validate the benefits of using the technologies. The "Cold Chain Guidelines" from the Food and Grocery Council (AFGC, 1999) and HACCP were used during these trials (FSANZ, 2005a). The performance of 'Organisation PDC's technology was validated using conventional data loggers and thermo couplers. The key environmental factors monitored were identity and temperature. However 'Organisation PDC' could provide extra sensors such as light, gas and shock sensing. The trials with 'Organisation PDC' were successful as the communication and accuracy of the sensors were reliable. Organisation D did not provide the researcher with any information on the trial with 'Organisation RFIDS', as the participant had signed a confidentiality agreement with that organisation.

**The interviews for Organisation E** in both rounds were conducted with the Product Quality and Third Party Co-ordinator of a multinational confectionary organisation. The researcher and chief investigator were in attendance. The first interview was conducted on the 21<sup>st</sup> September 2005, at 1:30 p.m. in a suburb of Sydney and took approximately 42 minutes. The second interview was held on the 6<sup>th</sup> December at 11:00 a.m. and took approximately 1.30 hours and was recorded using a portable digital recorder. The participant was heavily engaged in the quality assurance of the third party processes of the organisation. This involved packaging materials suppliers and third party manufacturers in Australia and overseas. As a result of this, the participant was able to offer significant insights into the quality assurance processes and policies of the organisation.

Organisation E is a multinational organisation that manufactures a variety of confectionary products, including ice-cream and other dairy products. The majority of the ice cream products are shipped by road, sea and occasionally by air. This organisation sources raw materials, including milk products, from a number of suppliers world-wide and manufactures products mainly for sale in Australia, New Zealand and South-East Asia. Imported finished products are required in peak seasons. The ice cream and frozen products are temperature

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sensitive. Change of temperature can cause changes to the shape and taste of these products. The cold chain management of many of these products requires storage and distribution to be at minus 22 degrees centigrade. Organisation E contracts third party logistic service providers to provide refrigerated road and sea transport. It sells its products via a large number of retail outlets. The organisation is not directly responsible for the retail sale of its products.

The Product Quality and Third Party Co-ordinator described many aspects of the procurement, processing and distribution of the organisation's products. He indicated that some trials had been conducted using conventional data loggers, but the loss of such data loggers, and the manual handling and recovery of such data, were both significant costs and, as such, barriers to the use of such equipment on a regular basis. During the summer, consignments of products can be subjected to heat shock and sustain deformation and change in their chemical and crystalline structures. Such consignments are withdrawn from sale and are held in cold storage, typically for over ten months while the nature and cause of the heat shock incident are investigated. This involves product control officers from Organisation E, legal officers, insurance assessors and logistics service providers. Due to the lack of accurate data on the timing and parameters of a heat shock incident, the legal case is most typically dropped due to a lack of adequate evidence. The spoiled products are then dumped.

The organisation conducts risk assessment of its suppliers on a six monthly basis. These are incorporated into the procurement management strategies of the organisation. Risk assessment of the third party logistics, warehousing and retail agents in the distribution is less active. The participant recognises that the variability of handling conditions of the logistics service providers in their distribution chain is a major source of risk exposure for the organisation. Some trials have been conducted with data loggers and RFID technology, but with limited success. The organisation is developing a strategy to improve the monitoring and quality control of its distribution chains, but the details of this strategy are pending further information and experience with time-temperature monitoring technology. This strategy envisages pallet level monitoring of time-temperature environments throughout the distribution chain, across multiple third

party providers in each chain. Data loggers have proved to be reliable, but are relatively expensive when they are frequently lost or not returned. They have a long life, can be readily reused, have a simple mode of operation, but are relatively cumbersome when placed amongst the product packaging.

A key element of the distribution chains for Organisation E is the nature of the ownership channel. The organisation deals with many different product lines and ownership of products along the distribution chain that are defined by contracts. These vary across distinct product lines and also with different third party service providers. The critical points of change of ownership of products in the distribution chain are determined by such factors as the identity of the goods handlers, the geographic location of the goods and the particular conditions associated with a product line and even an individual consignment. In practice, the actual timing and conditions of the handover of ownership of goods is often not clear to the parties directly involved. The organisation saw brand image as critical to the success of its continuing marketing and sales and so was concerned that all phases of the distribution chains complied with its own high standards of handling and quality assurance.

## **4.2 Approach to Qualitative Analysis**

As described in Miles and Huberman (1994), the researcher needs to employ a range of visualisation, analysis and interpretation tools for seeking to understand what is happening with the case study and how processes are evolving. The key processes in this data analysis are:

- The formulation of descriptions, or making complicated things understandable, by reducing them to their component parts (Bernard, 1988). This formulation needs to take place without excessive reductionism, so that the description remains true to the data and phenomena being observed; and
- The formulation of explanations, or making complicated things understandable, by showing how their component parts fit together according to some rules (Bernard, 1988).

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Miles and Huberman (1994) advocate the use of display formats, namely matrices and graphical networks, to support these two processes of description and explanation. In this research cause and effects matrices have been developed from Miles and Huberman (1994), particularly to assist in the formulation of descriptions by breaking the codes derived from the data into entries in tables. These analysis techniques were also useful in uncovering issues and relationships in the data, and assisting in the derivation of interpretations and viable explanations (Halldorsson and Aastrup, 2003). The rigorous analysis of the data required in order to meaningfully populate these tables enabled the researcher to uncover many aspects of the data that were not immediately evident from reading and listening to the transcripts.

To assist in further analysis and to formulate explanations, a network diagramming convention was used, based on a combination of concept diagrams and causal diagrams. The nodes in this network were derived from concepts identified from the coding of the data. Causal relationships were used to link these concepts, based on a detailed analysis of the transcripts. Only causal relationships that had been identified by the participants were included in these diagrams. The strength of these causal relationships was coded as “very strong” and “strong”. These were established on the extent of emphasis placed on the relationships by the participants. For example, should a respondent be adamant about an issue, it would be noted as very strong. In contrast if there was little emphasis it would be coded as strong.

A causal diagram was developed for each interview, and then a summary network for each case study was developed based on similarities and differences between the models derived from the two interviews. The aim of this process was to reduce overlap in the models in order to facilitate the formulation of explanations. Tables were used to assist the identification of themes and variations in the data. The causal diagrams provided greater insight into the structure of the relationships present within each case study and in particular, the development of an understanding of what was happening within each case study. In each case, an extensive analysis was conducted of the relevant transcripts in order to saturate the tables and networks with information derived from the case study data.

### **4.3 Example of Data Analysis**

After the transcription process was completed, the interview data in each transcript were examined using qualitative analysis methods that developed interpretations via coding and consideration of multiple alternative explanations of the phenomena being described in the interviews. In addition, analytic notes made by the researcher were developed during the coding process to add clarity and meaning to the transcript, as well as helping to revise and improve the coding structure (Miles and Huberman, 1994). The key issues were then identified and compared across the cases to look for similarities. These interpretations and explanations were then critically analysed to review how they were grounded in the data, the extent to which they were mutually self-consistent and how they provided plausible explanations of the processes and issues raised by the participants.

The specific qualitative analysis techniques employed focussed on the development of matrices that characterised the relationships between the effects and outcomes identified from the interviews. Graphical models were then developed that sought to characterise and explain the nature of the cause-effect relationships present in the data.

#### **4.3.1 Summary of the Steps for Conducting the Data Analysis**

This section describes the techniques used to analyse the data collected. The main steps incorporated in the data analysis process are:

1. The recording of the interviews were transcribed within 24 hours of being conducted;
2. The transcripts and field notes were thoroughly read for general ideas, after which summaries were made of each interview and emerging patterns and themes noted;
3. In order to develop headings and codes, these themes and the initial questions were employed, with transcripts and all other available data being coded accordingly;

4. From each source of data the contents were arranged under the headings that were suggested by the codes and were then related to the research questions;
5. Data from multiple sources were recorded under separate columns for each research question and theme. Further searches for contradictory or confirmatory data were undertaken;
6. The data sources were then re-read and employed as a framework to guide in the writing of case study profiles and descriptions of the processes covered by the participant (s);
7. Participant validation was achieved by returning draft copies of the case study and method descriptions back to the participants in an effort to gain confirmation of their accuracy and consistency;
8. Three matrices and the causal diagrams were employed as within-case displays to assist in visualisation and interpretation; and
9. The method of similarities was employed to identify patterns in a cross-case analysis, over all five case studies.

### 4.3.2 Effects-outcomes Matrices

Each case study generated three effect-outcome matrices. The following provides a brief summary of the contents for each matrix :

#### *Change Matrix*

The *Change Matrix* identifies three categories of changes:

- *Immediate Changes* or *Primary Changes* are direct effects, or consequences that follow immediately from changes implemented in the participant organisation;
- *Secondary Changes* or *Spin-offs* are side effects, some of which may not have been fully anticipated by the participants; and
- *Preferred Changes* are what the organisation would like to do, but have not yet been achieved.

Within this table each of these categories is further analysed according to three perspectives. These are *Systems*, *Processes* and *Relationships to supply chain*



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*partners*. *Systems* examines changes in wireless technologies such as RFID, data loggers and Nano-Corn Node technology for time-temperature monitoring. *Processes* focusses on internal and external process changes. *Relationships to supply chain partners* involves relationship between supply chain members.

### ***Effects Matrix: Direct, Meta, and Side Effects***

The *Effects Matrix* displays three categories of changes:

- *Direct Effects* are the direct result of primary changes. These are effects that operate directly upon something in the organisation.
- *Meta Effects* occur at a higher level, such as policy changes that are developed in order to achieve an operational change; and
- *Side Effects* happen as an additional or secondary result of change. They are outcomes of direct effects that are not immediate consequences of these changes.

In addition, for the three categories in the *Effects Matrix* the identified changes are classified as having (- negative), neutral (no effect) or positive (+ positive) outcomes.

Within this matrix each of these categories is further analysed according to three perspectives. These are *Application objectives*, *As seen by administrator* and *As seen by partner*. *Application objectives* examines changes on wireless technologies such as RFID, data loggers and Nano-Corn Node technology for time-temperature monitoring. *As seen by administrator* focuses on the participants' opinions and attitudes towards time-temperature monitoring equipment. *As seen by partner* involves the opinions of supply chain partners towards the use of time-temperature monitoring equipment. However, this level is beyond the scope of the present research since no supply chain partners were involved in data collection.

### ***Explanatory Effects Matrix***

The *Explanatory Effects Matrix* displays the antecedents of various outcomes. It demonstrates three categories of effects:

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- *Short-term Operational* effects are those that emerge from the day to day processes. For example they occur within one operation or consignment.
  - *Mid-term Tactical* effects are those between the *Short-term Operational* and *Long-term Strategic* categories. They have shorter time frames and narrower scope than strategic plans. For example, within a week to a year.
  - *Long-term Strategic* effects are the process of developing and analysing the organisation's mission, overall goals, general strategies and allocating resources. Typically this involves a period of two to five years.

In addition, this matrix includes two further analyses columns. These are *Assessment by the researcher* and *Description of Changes*. *Assessment by the researcher* columns is where the interviewer can add personal insight based on the following notations: “+ +” (very effective), “+” (effective), “0” (no opinion), “-” (ineffective) and “- -” (very ineffective). *Description of Changes* columns are based on changes and effects from the interview.

Within this matrix each of these categories are further analysed according to two perspectives. These are *System* and *Process*. *System* changes focuses on wireless technologies such as active RFID, data loggers and Nano-Corn Node technology for time-temperature monitoring. *Process* focuses on internal and external process changes.

### 4.3.3 Development of Causal Diagrams

Causal diagrams were also developed based on Miles and Huberman (1994). This aimed to determine causal relationships between factors identified as being significant in the data. They suggested that the researcher first determine:

- Which factors identified in the analysis might logically influence other?
- Which factors are likely or unlikely to be associated with each other?
- Which factors are dependent on the existence of others in order for them to have causal relationships?

The construction of a causal diagram is composed of three main components, which are input (independent variables or factors), intermediate processes and

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output (dependent variables, consequences or responses). There are seven steps to the development of the diagrams. These are described in some detail below, drawn from (Miles and Huberman, 1994, Gharajedaghi, 1999, Fahrenkrog *et al.*, 2002, Sherwood, 2002):

- ***Defining the Objectives of the Model and the Feasibility of the Research:*** these objectives led to identifying key questions:
  - What are the main issues to mention and evaluate?
  - Is the intervention directed towards the adoption of time-temperature monitoring equipment as a whole or is it limited to some sections with the organisation?
  - What do we want to measure?
  - What will be independent and dependent variables?
- ***Investigating Data Availability in the Interview Transcripts:*** within this research a deductive strategy was adopted:
  - What are the data requirements?
  - Are all the necessary data available?
  - How can one solve problems of missing or deficient data in the interview?
  - How is it possible to use interview notes?
- ***Specification of the Model:*** the researcher considers questions including:
  - What are direct or indirect links in the model?
  - How strong are they?
  - Can the information in the first round interviews be linked to the second round interviews?
- ***Collecting, Analysing and Transforming the Data:*** the quality of a causal diagram depends to a large extent on the reliability of the interview dataset.
- ***Estimating the Importance and Sequence of Issues:*** this stage is the most exacting as the researcher has to consider very carefully the sequence of

variables and also the status of each issue, including relative strengths or weaknesses. This stage requires careful analysis by the researcher because the variables were found to be more complex than the researcher initially thought.

- ***Testing and Validating the Network:*** the development of a causal diagram can reflect a researcher's bias, misinterpretation of the interview transcript and a limited amount of information being available through the data gathering processes. The validity of a causal diagram can be enhanced by ensuring that its construction is grounded in the available data. This is done by returning to the transcripts in order to improve the accuracy of each causal diagram, and hence heightens its validity and reliability. During the construction and review phases of each casual network, each component of the network is linked to elements from the transcripts and other available data using citations. A causal diagram can be considered to be fine tuned when it can be described in writing.
- ***Interpreting the Results:*** in this final step the data from round one and round two interviews are compared to develop a summary causal diagram. This is achieved by looking at the similarities and differences between the inputs, processes and outcomes within each case. Based on this process the final causal diagram is developed.

Following the development of these displays it was possible to compose an overall causal diagram display to depict the assumed relationships between the variables more accurately for each case studied. In addition, short explanations by the researcher for each relationship in each case study are provided on the causal diagrams. Each relationship in a causal diagram was assigned either a positive or negative rating to indicate the nature of its effect and a reference to supporting quotations in the transcripts. The causal diagrams provide a grounded model for each case study and are supported by commentary in the text to explain the relationships identified.

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#### **4.3.4 Steps for Development of Cross-case Analysis**

Following the development of the effects-outcome matrices, a cross-case display analysis was developed in which similarities between the cases were identified. Miles and Huberman (1994: 172) stated that cross-case analysis should be seen as an attempt “to see processes and outcomes across many cases, to understand how they are qualified by local conditions and thus to develop more sophisticated descriptions and more powerful explanations”. Merriam (1998:195) stated that “the interpretation of multiple case studies can involve both within-case and cross-case analysis, with the latter seeking to build abstractions across cases”.

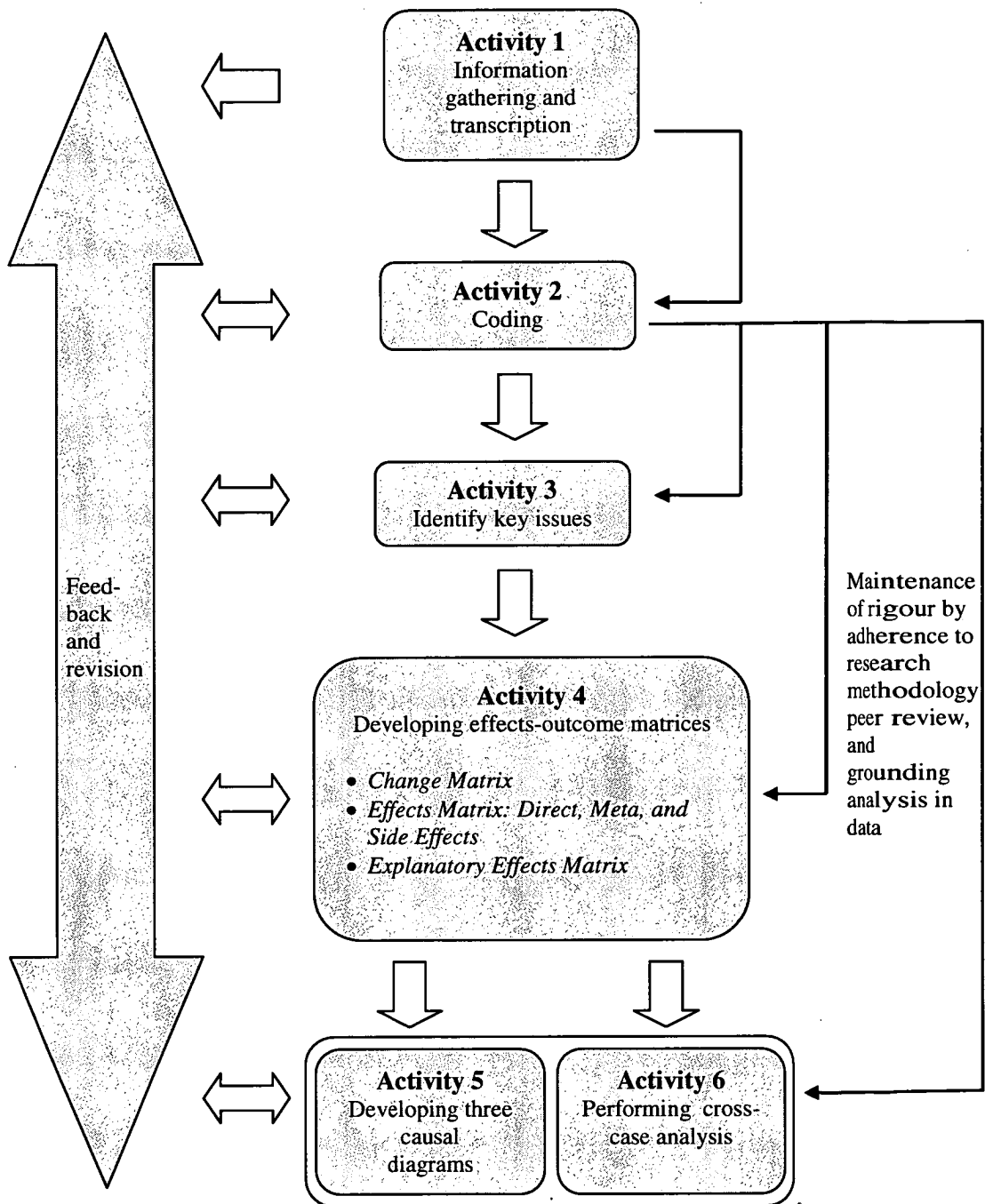
Commbs (1999) cited three possible strategies to consider when preparing to conduct cross case display analysis involved case-oriented strategies:

1. Case-oriented strategies focus on individual cases and seek out patterns, associations, causes and effects that exist within each case. Other, comparative cases are then considered for generalisability (Ragin, 1987);
2. A variable-oriented strategy is more conceptual in nature and pays greater attention to the function of key variables driven by theory. The majority of cases are normally involved and the researcher is seeking to identify broad patterns across multiple cases and places less focus on a case-to-case comparison (Runkel, 1990); and
3. The third strategy is a combination of the two previous approaches and focuses on a standard set of variables to analyse individual cases in detail (Miles and Huberman, 1994).

Figure 4-1 summarises the six primary analysis activities adopted in this research. It depicts the first Activity, 1 where the data from the interviews were transcribed. The second Activity 2 involves the coding of these that then moves to the third step Activity 3 where key themes are identified. Activity 4 is central to the research analysis process, within which effects-outcome matrices are constructed for each of the five case studies. The outcome from this then supports two parallel, final Activities 5 and 6. Activity 5 involves the development of a causal diagram while Activity 6 is based on a cross case analysis. The approach follows the recommendations made by Miles and Huberman (1994). These activities are

not a linear process because the output of each later Activity 1 is feedback to revise each of the earlier activities.

Activities in 3-6 are grounded in the data gathered in Activity 1 and the coding from Activity 2. This grounding, plus adherence to a strict research methodology and peer review, add to the rigour of the analysis and interpretation.



**Figure 4-1. The Analysis Process**

### 4.3.5 Example of Cause and Effects Matrices Data Analysis for Organisations A and E

This section will demonstrate how the themes became evident from the analysis of the transcripts of the interviews conducted in Organisations A and E. A similar

analysis process was adopted for Organisations B, C and D. The results for these can be found in Chapter 5. One reason that Organisation A was chosen as an example of the analysis process was that this organisation had strong support for the use of active RFID technology for time-temperature monitoring. Without prompting, this participant spoke of the importance of return on investment (ROI) in the adoption of active RFID technology. While Organisation E had a quality assurance orientation, Organisation E recognised the importance of cold chain quality assurance and the nature of the case for the adoption of time-temperature equipment for QA purposes. The adoption of time temperature monitoring equipment could provide businesses with data that can be used as evidence of (non) compliance with quality assurance standards and so reduce the cost of court cases. The analysis was based on quotations drawn from the transcripts. The unit of analysis was the phrase or individual utterance of the participant. Line numbers from the printed transcript were used extensively to identify where references are located.

For Organisation A the *Effects Matrix: Direct, Meta and Side Effects* will be presented. The information for Organisation E will be based on both a *Change Matrix* and an *Explanatory Effects Matrix*. Similar qualitative analysis techniques were applied to each of the remaining three cases. The analysis techniques for within a single case analysis, described in Miles and Huberman (1984, 1994), were particularly useful in uncovering issues and relationships in the data, and assisting in the derivation of interpretations and viable explanations. These displays had the advantage of showing all the relevant responses from each participant on individual sheets, that later enabled comparisons between the responses from all participants.

#### **4.3.5.1 Analysis of Organisation A**

As soon as possible after the interviews, the recordings were transcribed and analysed. The emergent themes were then further analysed as shown in Table 4-2. From the results of Organisation A, it became apparent that this participant supported the adoption of active RFID technology for quality assurance purposes. Without any prompting he offered the following comments:



*"I am a huge fan of RFID, I think it has got enormous potential. But it is demonstrating to people who do not have that background and that knowledge what the pay back is; how we actually recoup our investment" (Case A: 15-18).*

He was also aware that, even with exposure to the technology, many people fail to understand the importance of the information it provides. This view was offered in response to the following question. "What was the purpose of each of those projects?"

*"With these credit card data loggers, people who receive them do not recognise the value of them. Ok? Because they see the physical object and they do not understand the value of the information in it, so they do not recognise the real value of it, so they do not treat it as an object with great value" (Case A: 122-126).*

The determination of ROI on active RFID technology is a key issue in justifying the use of this technology. This view was offered in response to the following question. "Do you consider ROI to be an important issue in terms of the economic analysis of the use of active RFID technology?"

*"Absolutely, this, at the end of the day, this is a business. If we make a decision of where we put our development funding, do we buy new equipment, do we employ people, do we set up a marketing campaign, do we develop new products, do we put up RFID? So the economic rationale for doing these things is very, very important" (Case A: 353-357).*

He also commented that the calculation of ROI is not simple and there was a need to demonstrate the actual ROI/payback on RFID. The response to the question. "Do you consider ROI to be an important issue in terms of the economic analysis of the use of active RFID technology?"

*"The problem is it's very difficult to establish what the economics of it are, and it's a critical issue we touched on earlier. It's very, very easy to measure the front end cost of RFID. To get the RFID equipment, the*

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*‘Organisation RFIDS’ service that we currently have, I really, I couldn’t mount the another side of the argument I couldn’t make the other side of the case” (Case A: 357-362).*

***Open and Axial Coding Example: Organisation A***

This section describes the preparation of two stages of data coding involving open and axial coding. The researcher went through the process of assigning codes to the interview data. Table 4-2 shows an excerpt from the interview transcript of Organisation A. It demonstrates the initial codes assigned to the various aspects of the research transcript. Line numbers in quotations from the transcript were used to allow the researcher to easily refer to the exact location of the source in the transcripts.

At this stage, the initial open codes tended to be more descriptive than analytical. Many of these terms were found to recur across the cases. Preliminary codes associated with these constructs were recorded and emergent concepts were ordered and arranged into meaningful groups for further analysis. The aim of the axial coding was to explore the relevance and appropriateness of the initial set of codes. By use of the effects matrix, the researcher can view the sets of responses and examine them for consistencies across questions that reflect themes, which emerge from the data. The researcher also reviewed the data in order to determine if there were themes, or ideas that assisted in the understanding of the findings. For example, in Table 4-2 the term “balance RFID investment against return”, “financial model supporting RFID investment” and “value of ROI” were aggregated to a higher-level axial code “achievement of ROI on RFID technology”.

**Table 4-2. Open and Axial Coding Examples: Case A**

Quote from Transcript	Interpretation	Initial Code	Revised Code	Category of Words
<i>We have just spent \$2.5 million in Dover completely refurbishing that plant. We are confident in doing that because we can say the cost is \$2.5 million, it slices a million dollars a year out of our costs, pays back in 2.5 years therefore the board is confident to say well yes. Here's the money because we can see an argument, in an accounting sense it works. Not only that we can go back in 12 months time and say, did I do that? We expected it to slice a million dollars out, did it actually do that? With RFID you can't do that, and this is one of the problems, and it's a similar issue that is faced by new product development (365-374)</i>	The company needs to balance the investment decisions on RFID with capital expenditure, the development of new products and the expenses of marketing campaigns	Balance RFID investment against return	Achievement of ROI on RFID technology	Issues associated with ROI on RFID technology
<i>The economic rationale for RFID is essential but it's almost impossible to calculate and that's why I'm so excited that somebody is having a hard look at how to mount that argument. OK. It is a critical issue (377-380)</i>	The economic rationale for RFID is essential, but is impossible to calculate	Financial model supporting RFID investment		
<i>We need to know what the return is, and at the moment we have no measure of what the potential benefits are. It's a question of valuing information and putting a dollar value against information and that's very, very difficult. If we can guarantee our cold chain, will that increase sales and increase profitability? Absolutely! By how much? I've got no idea, and this is the very hard bit. This is where it becomes so difficult. So the important issue is, what's our return? How to measure our return on this investment? And measuring the cost the investment is very easy, measuring the return is the killer (398-406)</i>	All questions of investment in RFID ultimately come back to estimating the value of ROI	Value of ROI		

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**Developing an *Effects Matrix: Direct, Meta and Side Effects: Organisation A***

The researcher entered direct quotes into the matrix table, including all of the outcomes mentioned in the interview. The aim was to get to the essence of the interview material as appropriate for each cell. Table 4-3 shows the *Effects Matrix: Direct, Meta, and Side Effects* based on the discussion of the use of active RFID in Organisation A. The *Effects Matrix* presents the *Direct, Meta* and *Side Effects* from the *Systems* and *Relationship* within the *Program* perspectives. Within this case, the researcher focused on the opinion expressed by the participant in terms of the ROI/ payback period and economic perspectives.

Direct quotations have been used to describe changes in the appropriate cells because Miles and Huberman (1984b:124) stated that the “decision rules for data entry must be clear”. The *Effects Matrix: Direct, Meta, and Side Effects* concentrates on the outcomes of each of the variables concerned and their effects on other variables and areas associated with the adoption of active RFID technology. The outcomes of the technology within Organisation A are characterised as having positive and negative effects. Each variable was analysed for positive, neutral (no opinion) and negative effects against specific outcomes and whether they were considered by the participants to be direct or indirect relationships.

**Table 4-3. Effects Matrix: Direct, Meta and Side Effects: Organisation A**

<i>Perspective</i>	<b>Direct Effects</b>			<b>Meta Effects</b>			<b>Side Effects</b>		
	<b>negative</b>	<b>neutral</b>	<b>positive</b>	<b>negative</b>	<b>neutral</b>	<b>positive</b>	<b>negative</b>	<b>neutral</b>	<b>positive</b>
<i>Application objectives (as interpreted by the researcher): Systems</i>	<p><i>But it is demonstrating to people who do not have that background and that knowledge what the pay back is; how we actually recoup our investment (15-18)</i></p> <p><i>(The payback period on RFID is the key issue)</i></p>		<p><i>I am a huge fan of RFID, I think it has got enormous potential (15)</i></p>	<p><i>The problem is it's very difficult to establish what the economics of it are. . I couldn't mount the another side of the argument I couldn't make the other side of the case (361-362)</i></p> <p><i>(The calculation of ROI is not simple)</i></p>					
<i>Relationships</i>	<p><i>With these credit card data loggers, the people who receive them do not recognise the value of them (122-123)</i></p> <p><i>(People do not recognise value of data loggers)</i></p>			<p><i>Because they see the physical object and they do not understand the value of the information in it so, they do not recognise the real value of it, so they do not treat it as an object with great value (122-126)</i></p> <p><i>(People discard value of data loggers)</i></p>					

#### 4.3.5.2 Analysis of Organisation E

The results of the coding process for Organisation E revealed that a primary theme was that of quality assurance. It appeared that when Organisation E implemented a pilot study with 'Organisation RFIDS', it was influenced in its strategy to adopt time-temperature monitoring technology. The pilot study sought to understand the nature of the adoption of time-temperature monitoring of perishable foods throughout critical segments of the supply chain. While innovation can sometimes be substituted as a direct replacement for systems or processes in an existing organisation, the introduction of most innovations typically has a more widespread effect throughout the organisation (Miles and Huberman, 1984b).

From the results in Organisation E, it became apparent that the cost of using data loggers was justified on the basis of:

- Reducing the costs associated with inspection and testing of imported goods; and
- Having quality assurance that the goods had been kept at the required temperature, or otherwise be able to pinpoint the cause of any problems. This would provide evidential material for use in legal disputes over problems with handling and storage.

Without any prompting this participant offered the following comments:

*"We import some blocked ice products, which are more susceptible to heat shock, very sensitive to temperature changes, and we had a couple of instances where whole containers had to be rejected and dumped, at a cost in excess of \$20,000. Now, this definitely justifies spending extra money and using the data loggers, we may be able to reduce our inspection and testing program of imported stuff, we were definitely able to monitor and have assurance that product has not been heat shocked during the journey, and if it has been heat shocked, it might have happened, for example, in Europe or China during the loading. So that will enable us to pinpoint the*

*root cause of the problem. We also had a few quality issues with our distribution here in Australia. For example, we had an issue that ice cream was left at the dock at a temperature of 5°, approximately 5°, for several hours. If we had a cheap data logger, or some sort of control, we could prove that the ice cream was subjected to heat shock at that time, at that place. We had to go through a court case to argue our point that when it left the factory it was in good shape” (Case E: 41-52).*

The participant from Organisation E then went on to identify the costs of keeping the stock in a warehouse including:

- The cost of production, transportation and storage;
- The cost of quality assurance;
- The cost of writing off damaged products and dumping of such products;
- The cost of involvement of the finance department in logistics and quality assurance; and
- The use of preparing a law suit.

In particular, it was stated that considerable time needed to be devoted to addressing these concerns.

*“Well, also with the insurance companies, if we claim damage, then we need to deal with the insurance company. We need to deal with their shipper, and it can take approximately 10 months to get any resolution. In the meantime, we keep the stock in the warehouse, and we pay for it and nobody will reimburse us for that. So, sometimes we enter into negotiations, and we say, okay, well, we are going to dump the product, because we paid that sort of amount of money per pallet, per week, and it keeps accumulating. So the cost, this cost, the cost of quality, the cost of writing off the product, dumping the product, finance department is being involved in the logistics and quality assurance. So all together it certainly justifies spending an extra few bucks buying these data loggers even if it is just one year data logging” (Case E: 58-66).*

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Organisation E reported that there were many potential positive outcomes from the use of time-temperature monitoring equipment:

- An improvement in third party processes;
- Better control over distribution of finished products; and
- The possible use of GPS transmitters that could also help to locate trucks and identify quality issues with products, including in the case of accidents. These quality issues could then be linked to consumer complaints, and the root cause of such problems identified.

Further potential positive outcomes can be categorised according to the time-frame on which they can be expected to be achieved:

- Immediate: elimination of secondary costs associated with storage, processing and investigating heat shock incidents;
- Intermediate: the driving of change through the distribution chain, making third party logistics service providers and warehouse managers more aware of the need for compliance with the quality control standards required by Organisation E for the transportation, handling and storage of their products; and
- Strategic: brand name protection through monitoring of quality control standards across their supply and distribution chains.

When asked what were the outcomes that can be attributed to the use of time-temperature monitoring equipment in each of those projects, the participant replied that:

*“We believed that this was would improve our third-party processes. This would give us better control of what was happening during distribution of our finished product for example. Because once the product leaves our third party warehouse, then we do not have any control over it. So, and if we use transmitters in the future, if we could use transmitters, then this would give us perhaps better, even better control, because we would know the location of the trucks, the timing and in case of accidents, in case of quality issues with the*



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*product, linked back to consumer complaints. We would be able to pinpoint the root cause of the problem or the issue” (Case E: 251-257).*

***Open and Axial Coding Example: Organisation E***

After each interview was conducted a transcript of the interview was created. Participant validation (Neuman, 2000) was achieved by providing the participant with detailed notes of the respective interviews. These notes were produced following the open and axial coding processes described above and the participants were asked to provide feedback on the validity of the notes with respect to the interviews. In each case minor changes were suggested by the participant that corrected factual data, but did not alter the essential content of these notes.

The open coding process in Organisation E involved initially coding at the phrase level. The interview data was coded a second and third time to determine the codes through an axial coding process. For example, initial codes presented in Table 4-4 are: “have some quality issues with suppliers”, “third party collaboration on time-temperature monitoring” and “third party collaboration on time-temperature monitoring”.

The results of the coding procedures for Organisation E suggested that quality control of third party processes is important. Despite the complexity of the ownership channels in Organisation’s distribution chains, sharing of information between owners was seen as desirable in terms of recognising the partnership arrangements established through their distribution contracts and required in order to achieve their strategic outcomes. Organisation E was clearly the supply chain leader in the supply chains in which it participated, was confident of its own quality assurance standards, and sought to achieve continuous improvement in the quality assurance practices of all of its supply chain partners.

The achievement of ROI was so obvious with any of the available monitoring technologies that it was not a major issue for a solution that integrated with the business and logistics models of the organisation. The major issues identified were to find and adopt a technology that fitted and enhanced those standards and

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procedures, not imposed new, disruptive business models. The trial with a particular RFID tag had the outcome of providing experience with a satisfactory monitoring technology. However the business model of licensing and data management imposed by the provider of the RFID tags did not integrate with the Organisation E's established business processes.

Organisation E is very dynamic in its product development and rapid product to market cycle. It had in place well defined quality control standards and risk assessment and audit procedures. They saw the need to implement time-temperature monitoring equipment on both their supply and distribution chains as production requirement, not just an interim measure for validating their third party handling and storage standards. The use of time-temperature monitoring equipment was a strategic initiative to bring the high standards of manufacturing and production that Organisation E already applied to its own operations. This would then facilitate the rapid roll-out of new products by quality assuring the distribution chains of such products, so that its brand image was protected and its product innovation was transparent to the marketplace.

The supply chain leader has the buying, manufacturing and distribution power to drive this strategy through its supply chain partners. As such, ROI was not a major issue in the consideration of the adoption of time-temperature monitoring equipment because the magnitude of secondary costs associated with heat shock incidents far outweigh the costs associated with the adoption of such technology. The analysis demonstrated a general lack of awareness of the need for quality assurance by the third party logistics service providers in the distribution chain, despite the existence of well documented standards on handling and storage (Keen and Thamworrawong, 2006).

**Table 4-4. Open and Axial Coding Examples: Organisation E**

Quote from Transcript	Interpretation	Initial Code	Revised Code	Category of Words
<i>We look for monitoring the temperature in the container. We also would like to use some kind of data log or temperature monitoring for some of our own materials because we have had some quality issues with our suppliers (23-25)</i>	Use data loggers for temperature monitoring of containers to assure the quality of products	Have some quality issues with suppliers	Quality assurance	Suppliers quality control process
<i>They throw the container and then it is our responsibility from then on as soon as it leaves their factory. And that includes several transport companies, shipping companies, and anything can happen during the journey and a temperature monitoring would give us a clue (26-29)</i>	Responsibility for the goods in supply is with third parties from the point of dispatch by the supplier	Third party collaboration on time-temperature monitoring		
<i>We would like them to attach a particular data logger to a particular palette that is part of the shipment. Identify that palette for easy retrieval, and then we would like to be notified that this particular data logger is in, on the shipment. And, then we would retrieve, or our warehouse person would retrieve that data logger. And, I that they downloaded for us or we download it here, and check the temperature. And that would be part of the quality-control process (117-123)</i>	Would like third party suppliers to activate data loggers when the products leave their premises, and for monitoring at the palette level. This would identify the palette and the data could be downloaded on arrival and checked for quality assurance purposes	Third party collaboration on time-temperature monitoring		

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### Developing a *Change Matrix*: Organisation E

Table 4-5 shows the *Change Matrix*. As shown in Figure 4-1 the development of Change Matrix was derived from Activity 1 (Information gathering and transcription), Activity 2 (Coding) and Activity 3 (Identify key issues). The cell entries are direct quotes from the transcript, including all outcomes mentioned by the participant when describing specific changes in the organisation. A review of the codes from the matrix shows the changes in attitudes, concepts, understanding of time-temperature monitoring equipment within their cold chains. The participant demonstrated a positive attitude toward the use of time-temperature monitoring equipment. A review of the coding showed that the participant has a “strong view” on the use of time-temperature monitoring technology. For example:

*“We were definitely able to monitor and have assurance that that product has not been heat shocked during the journey” (Case E: 45-46).*

In Table 4-5 the *Immediate Changes* column has the most entries followed by the *Secondary Changes* column, while the *Preferred Changes* column offers the least amount of possibilities. The *Intermediate*, *Secondary* and *Preferred Changes* are shown as they apply to each of the perspective which the researcher defined as *Systems*, *Processes* and *Supply chain partner relationships*. The researcher has characterised these outcomes from three different perspectives: changes in *Systems*, *Processes* and *Relationships to supply chain partners*.

### Results from the *Change Matrix*

At the level of *Immediate Changes*, the potential benefits that time-temperature monitoring equipment can bring to Organisation E are shown in Table 4-5. The fourth column in Table 4-5 shows *Preferred Changes* that Organisation E wished to achieve in the future. We can see by moving horizontally across in the *Processes* rows that *Primary Changes* tend to affect *Secondary Changes* and *Preferred Changes*. In this case the potential benefits of time-temperature monitoring equipment can lead to an improvement in third party processes and a decrease in insurance costs. In the right half of the matrix, we can note that since the implementation of the time-temperature monitoring equipment, the third party

processes have become more transparent, also warehouse and purchasing processes are more clearly visible.

Comparing *Immediate Changes* with *Secondary Changes*, we see that Organisation E is likely to be able to reduce the cost of operations. Within this matrix, we can see how *Immediate Changes* lead to *Secondary Changes*. We can see how first level changes lead to later consequences (*Secondary Changes*) and we can see how *Preferred Changes* lead to future plans of organisations. For example, looking at the *Systems* perspective the use of time-temperature monitoring equipment influences the ability of the organisation to monitor and pinpoint cause of problems arising from *Immediate Changes*. The matrix also shows this perspective, the ability to reduce operation costs in *Secondary Changes* leads to the ability to justify spending extra money and use time-temperature monitoring in *Preferred Changes*. Therefore, if Organisation E were to implement the time-temperature monitoring equipment, the matrix demonstrates that the organisation would be able to reduce operational costs and increase quality assurance of their products.

#### **Developing an *Explanatory Effects Matrix*: Organisation E**

Table 4-6 is aimed at understanding the effects of time-temperature monitoring equipment in Organisation E. It displays the *Explanatory Effects Matrix* for the organisation. The data was entered into each cell as direct quotes found in the transcript. Miles and Huberman (1984b:118), stated that “such a matrix helps clarify a domain in conceptual terms; it’s a useful first exploration tracing back-and forward- the emerging threads of causality”. In this case, the use of data loggers was interpreted for three timeframes: short-term operational (within a trip), mid-term tactical (weeks to one year) and long-term strategic (two to five years). Miles and Huberman (1994:148) viewed that “the matrix helps us understand things temporally”. According to the Table 4-6 it appeared that Organisation E had an issue with the quality assurance of products during the cold chain distribution. In this case, the researcher is looking for changes in the implementation of time-temperature monitoring equipment. These changes can occur in *Short-term*, *Mid-term* and *Long-term Strategic* timeframes. The timeframes include the initial changes (*Short-term Operational*), since one might

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expect that changes would occur as *Mid-term* and *Long-terms* changes. The rows of Table 4-6 deal only with the systems and processes in Organisation E. The purpose of this matrix is to elaborate the effects of the changes on these systems and processes. These effects are then analysed in terms of their *Short-term (Operational)*, *Mid-term (Tactical)* and *Long-term (Strategic)* outcomes. The researcher has added an *Assessment* column in order to indicate the assessments by the researcher of the effects being recorded.

### **Results from the *Explanatory Effects Matrix***

The data in the Table 4-6 shows the system and process associated with using data loggers across three different time periods. The use of data logger proved to have substantial implementation requirements which needed to be addressed in order to improve the quality assurance of products. The matrix helps the researcher to place any changes occurring over a given period in a clear context and to interpret their meaning.

It appeared that the ability to pinpoint causes of problems is the most important outcome not only for operational but also tactical and strategic levels. The system row shows us that the use of time-temperature monitoring equipment can improve third party process and also reduce the cost of operations. Other early changes identified that the use of time-temperature monitoring equipment for quality assurance of perishable foods throughout the distribution chain has significantly impacted at the *Short term*, *Mid-term* and *Long-term Strategic* levels.

**Table 4-5. Change Matrix: Organisation E**

<i>Perspective</i>	<i>Immediate Changes/Primary Changes</i>	<i>Secondary Changes/Spin-offs</i>	<i>Preferred Changes/What the organisation would like to do</i>
<b>Systems</b>	<p><i>We were definitely able to monitor and have assurance that that product has not been heat shocked during the journey (45-46)</i></p> <p><i>(Assure the quality of products)</i></p> <p><i>So that will enable us to pinpoint the root cause of the problem (47-48)</i></p> <p><i>(Pinpoint cause of problems)</i></p>	<p><i>We may be able to reduce our inspection and testing program of imported stuff (44-45)</i></p> <p><i>(Reduce operation cost)</i></p>	<p><i>This definitely justifies spending extra money and using the data loggers (43-44)</i></p> <p><i>(Costs justify the investment in buying RFID tags)</i></p> <p><i>If we had a cheap data logger, or some sort of control, we could prove that the ice cream was subjected to heat shock at that time, at that place (50-52)</i></p> <p><i>(Pinpoint cause of problem)</i></p>
<b>Processes</b>	<p><i>Would improve our third-party process. This would give us better control of what was happening during distribution of our finished product for example (251-252)</i></p> <p><i>(Monitoring and auditing of third party)</i></p>	<p><i>Because once the product leaves our third party warehouse, then we do not have any control over it (252-253)</i></p> <p><i>(Hard to control quality all along the cold chain)</i></p>	<p><i>We may be able to reduce our inspection and testing program of imported stuff, we are definitely able to monitor and have assurance that product has not had heat shock during the journey (44-46)</i></p> <p><i>(Reduction cost of inspection and testing )</i></p> <p><i>If we use transmitters in the future, if we could</i></p>

<b>Perspective</b>	<b>Immediate Changes/Primary Changes</b>	<b>Secondary Changes/Spin-offs</b>	<b>Preferred Changes/What the organisation would like to do</b>
			<p>use transmitters, then this would give us perhaps better, even better control because we would know the location of the trucks the timing and in case of accidents, in case of quality issues with the product, linked back with consumer complaints. We would be able to pinpoint the root cause of the problem or the issue (253-257)</p> <p>(Pinpoint cause of problems)</p>
<b>Relationships to supply chain partners</b>	<p>If we claim and damage, then we need to deal with the insurance company, we need to deal with their shipper, and it can be approximately 10 months to get any resolution (58-60)</p> <p>(Claims with insurance companies can take many months)</p>	<p>Had to go through a court case (52)</p> <p>(Go to court)</p> <p>We keep the stock in the warehouse, and we paid for it and nobody will reimburse us for that. So, sometimes we enter into negotiations, and we say okay, well, we are going to dump the product (60-62)</p> <p>(Cost of keeping stock in a warehouse)</p>	<p>So all together it certainly justifies spending an extra few bucks buying these data loggers even if it is just one years data logger (64-66)</p> <p>(Cost justify the investment in buying temperature monitoring RFID tags)</p>



**Table 4-6. Explanatory Effects Matrix: Organisation E**

<i>Perspective</i>	<i>Assessment</i>	<i>Description of Changes</i>	<i>Short-term Operational</i>	<i>Mid-term Tactical</i>	<i>Long-term Strategic</i>
<i>System: data logger</i>	+	<p>We had a couple of instances where whole containers had to be rejected and dumped, at the cost in excess of \$20,000. Now, this definitely justifies spending extra money and using the data loggers (42-44)</p> <p>(Cost of dumping of products)</p>	<p>We may be able to reduce our inspection and testing program of imported stuff. We are definitely able to monitor and have assurance that product has not had heat shock during the journey (44-46)</p> <p>(Reduce cost of inspection and testing)</p> <p>We could prove that the ice cream was subjected to heat shock at that time, at that place (51-52)</p> <p>(Root cause of problems are identified)</p>	<p>So, all together it certainly justifies spending an extra few bucks buying these data loggers even if it is just one years data logger (64-66)</p> <p>(Spend money on data loggers)</p> <p>Will enable us to pinpoint the root cause of the problem (47-48)</p> <p>(Pinpoint cause of problems)</p>	<p>Would improve our third-party process. This would give us better control of what was happening during distribution of our finished product for example. Because once the product leaves our third party warehouse, then we do not have any control over it (251-252)</p> <p>(Improve third party process and better control of what happen during distribution of finished products)</p> <p>So, and if we use transmitters in the future, if we could use transmitters, then this would</p>
<i>Process: monitoring through the</i>					

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<i>Perspective</i>	Assessment	Description of Changes	Short-term Operational	Mid-term Tactical	Long-term Strategic
<i>distribution</i>					<p><i>give us perhaps better, even better control, because we would know the location of the trucks the timing and in case of accidents, in case of quality issues with the product, linked back with consumer complaints. We would be able to pinpoint the root cause of the problem or the issue (253-257)</i></p> <p><i>(Problem could be definitive and conclusive as to who or what the problem are)</i></p>

## 4.4 Summary Reflections

The chapter began with a profile of the five organisations that took part in the main component this research. It has described the detailed analysis of the data. The process of generating the *Change Matrix*, *Effects Matrix: Direct, Meta, and Side Effects* and *Explanatory Effects Matrix* were explained, and examples were provided. Following this the procedures involved in the development of causal diagrams were described. Two cases were selected to illustrate the analysis processes.

## CHAPTER FIVE: FINDINGS

### 5.0 Introduction

The aim of this chapter is to present the findings of the analysis described in Chapter 4. Figure 4-1 presented the process of the analysis from the information gathering and transcription through to the end of the analysis. Within the five cases the findings were obtained through a process of coding and development of cause and effect matrices, as described in (Miles and Huberman 1984, 1994). A further process of analysis involved the application of causal diagram analysis. Finally a cross-case analysis was conducted.

### 5.1 Within-case Analysis

Within this section the findings are based on the analysis and interpretation through the following:

- Three matrices;
- Causal diagrams; and
- Summary of each case study.

#### *1. Findings from Three Matrices*

The interpretation presented in this section is focussed on the three matrices of results whose structure was described in the previous chapter. To recap, these matrices involve *Change Matrix* (Table 5-1), *Effects Matrix: Direct, Meta, and Side Effects* (Table 5-2) and *Explanatory Effects Matrix* (Table 5-3). In chapter 4 these were limited to examples of *Effects Matrix: Direct, Meta, and Side Effects* for Organisation A and *Change Matrix* and *Explanatory Effects Matrix* for Organisation E. The results of all five case studies will be considered in this chapter.

The *Change Matrix* involved extracting three levels of changes (*Immediate, Secondary and Preferred*). In turn, these were broken down to changes from *Systems, Processes and Relationships to supply chain partners* perspectives. Table 5-1 provides an outline of the changes and perspectives addressed in the *Change Matrix*.

Table 5-1. Change Matrix

Perspective	Immediate Changes/ Primary Changes	Secondary Changes/ Spin-offs	Preferred Changes/ What the company would like to do?
Systems			
Processes			
Relationships to supply chain partners			

The *Effects Matrix: Direct, Meta and Side Effects* was based on categories of changes from three perspectives: *Application objectives*, *As seen by administrator* and *As seen by partner* perspectives. Each level of change involves *Systems*, *Processes*, *Relationships* and *Performance* perspectives. Table 5-2 provides an outline of the changes and perspectives addressed in the *Effects Matrix: Direct, Meta, and Side Effects*.

**Table 5-2. Effects Matrix: Direct, Meta and Side Effects**

<i>Perspective</i>	<b>Direct Effects</b>			<b>Meta Effects</b>			<b>Side Effects</b>		
	<b>negative</b>	<b>neutral</b>	<b>positive</b>	<b>negative</b>	<b>neutral</b>	<b>positive</b>	<b>negative</b>	<b>neutral</b>	<b>positive</b>
<i>Application objectives (as interpreted by the researcher):</i>									
<i>Systems</i>									
<i>Processes</i>									
<i>Relationships</i>									
<i>Performance</i>									
<i>As seen by administrator:</i>									
<i>Systems</i>									
<i>Processes</i>									
<i>Relationships</i>									
<i>Performance</i>									
<i>As seen by partner:</i>									
<i>Systems</i>									
<i>Processes</i>									
<i>Relationships</i>									
<i>Performance</i>									

The *Explanatory Effects Matrix* extends the *Systems* and *Process* perspectives to include *Short-term Operational*, *Mid-term Tactical* and *Long-term Strategic* changes. In addition, it also supports analysis based on a *Description of Changes* as well as *Assessment by the researcher*. Table 5-3 presents an outline of the changes and perspectives addressed in the *Explanatory Effects Matrix*.

**Table 5-3. Explanatory Effects Matrix**

<i>Perspective</i>	<i>Assessment</i>	<i>Description of Changes</i>	<i>Short-term Operational</i>	<i>Mid-term Tactical</i>	<i>Long-term Strategic</i>
<i>System:</i>					
<i>Process:</i>					

The processes and scope of the issues involved in each of the three matrices have already been established in Section 4.3. In analysing the results for each case study the transcript for each interview was used to determine each variable and its effects on other variables and areas associated with the adoption of time-temperature monitoring equipment. Individual variables were scrutinised for positive and negative effects and whether they were deemed by the participants to be direct or indirect relationships, following Miles and Huberman (1994). The technique of counting, comparing and contrasting was applied during the analysis of these matrices. Each matrix, complete with coding, can be found in Appendix 2. A description for each of the three matrix tables is given in Section 5.1.1 – 5.1.5. These will be interpreted based on the different levels involved for the categories in each matrix.

For the purposes of clarity, references to elements of these matrices will be italicised in the remainder of the thesis.

**2. A Description of the Findings in Causal Diagram**

The causal diagram model aims at illustrating the cause and effect relationships associated with the adoption of time-temperature monitoring equipment in the different case studies. The structure of the model is based on concepts from Miles and Huberman (1984, 1994). The causal diagrams allow the researcher to analyse

the structure of cause-effect relationships and the consequences of change in individual variables upon outcomes. These relationships provide explanations for the process associated with the adoption of time-temperature monitoring equipment within cold chain distribution.

A dynamic version of the input-outcome model is used to evaluate the adoption of the technology within five organisations. The network illustrates the independent and dependent variables. Each of the nodes in this network represents a concept that has been identified by the participant as a key issue in the time-temperature monitoring of products through the supply chains. The identification and labelling of each of the concepts and relationships in this network has been closely derived from the coded transcript of the interview with the participants. While the causal diagrams have been provided in this section, for ease of reading they are also available in a larger format in Appendix 3.

In the sections to follow, for each case, with the exception of Organisations A and C, causal diagrams will be developed for Interview 1 and Interview 2. The participant in Organisation A was not willing to take part in the second interview. The Organisation C participant indicated a lack of interest in time-temperature monitoring equipment and so was not conducive to continuing to a second interview. For the remaining Organisations (B, D and E) the analysis will be followed by further causal diagrams based on the combining of Interviews 1 and 2. Similar issues were retained as one in the last matrix while the differences were identified between two issues were added. In this approach the aim is to reduce overlap in the models in order to facilitate the formulation of explanation.

### ***3. Summary of Each Case Study***

This section will provide a summary overview for each case study based on the findings from three matrices and causal diagram of findings as outlined in the previous section.



### **5.1.1 Case A**

Organisation A is a producer and an exporter of aquaculture products located in Tasmania. The organisation has been trialling active RFID technology for time-temperature monitoring from processing through to the end of the cold chains. Although the organisation is interested in active RFID technology, it needs to overcome concerns that are currently acting as barriers to its adoption.

Due to the relative inexperience of the organisation regarding active RFID technology, the size of the organisation and the degree of uncertainty regarding the actual benefits that the business would experience, the organisation had to take a cautious approach. In this case study the analysis revealed that this organisation was a follower organisation and not prepared to take risk unless convinced a return on investment would be achieved. This implies it tended to be unwilling to embrace new technology unless it could clearly demonstrate financial returns. However, prior to their active RFID initiative, Organisation A was very enthusiastic and employed RFID tags for a short period of time. The level of enthusiasm for active RFID technology and interest in developing a business case were characteristics that reflect on the level of active RFID technology knowledge and understanding possessed by the participant.

Organisation A operated 60 RFID tags and 3 RFID readers. The company had been using the technology along the entire cold chain that was from processing to the arrival at the end market destination of the various salmon products. Organisation A took a more traditional approach to how active RFID technology had been used within the organisation. Having already moved to a more customer and quality focused approach, the implementation of this technology did not require significant change. The only alteration was to create a means of confirming the correctness of strategy within cold chain management. Organisation A reported that they did not find it necessary to make significant changes to their on-going processes, due to the strong emphasis of their business on quality control of their supply chain management. In the initial stage of the introduction of the technology the company conducted pilot case studies with the involvement of the technology service provider. The main reason for conducting the pilot studies was to enable

temperature monitoring. It was seen as a critical factor in ensuring that the products were kept below a certain temperature at all times throughout the supply chain in order to be able to deliver products in premium condition. The company had experienced temperature abuse during the cold chain and the technology provided the means to pinpoint the cause of the problem during transportation of the salmon products.

### 5.1.1.1 Effect-outcome Matrices Findings

The structure and nature of analysis and interpretation of the effect-outcome matrices was presented in Section 4.3.2. Within this section the findings from the three matrices will be presented.

#### *Change Matrix: Organisation A*

This *Change Matrix* can be found in Appendix 2.1.1.

#### *Systems Perspective*

From a *Systems perspective* in the *Change Matrix* for Organisation A the majority of entries are in the *Immediate Changes* (24) column and the least number of entries are in the *Secondary Changes* (12) and *Preferred Changes* (8). For this case the overall effect of change in *Systems* tends to be more direct than indirect. This suggests that this organisation largely focuses on current issues, rather than planning for the future.

In addition, looking at the pattern of responses from the matrix it can be seen that the participant's attitude towards active RFID technology tends to be mixed. In contrast, a majority of the other comments by this participant were positive and enthusiastic about the adoption of the technology. The following quote illustrates the mixed views of Participant A:

*"I'm a huge fan of RFID, I think it's got enormous potential, but it's demonstrating to people who don't have that background and that knowledge what the pay back is; how we actually recoup our investment"* (Case A: 15-18).

*"We've got very excited about them [RFID technology]"* (Case A: 42).

*“Used them quite a lot for a brief time. They provide us with useful data”*  
(Case A: 42-43).

However, the participant went on to comment about the drawbacks of active RFID for time-temperature monitoring:

*“These cards themselves are very limited. I’m waiting for the newer version to come out”* (Case A: 52-53).

*“There is a little bit technology innovation to go with this”* (Case A: 54-55).

*“Quite happy with them but I would like to see them better”* (Case A: 56-57).

This negative attitude towards the technology was supported by the participant:

*“People who aren’t receivers and transporters are not prepared to handle the data loggers. They see it as an imposition and they also see it as probably giving us an undue insight into their business and they are not particularly happy with in fact being asked to spy on themselves. It’s pretty much how they see it”* (Case A: 106-110).

*“The receivers and transporters are very unwilling to do that [use RFID technology] because it is seen as being intrusive, there is a mindset there that we have to get over if we have to make this work”* (Case A: 114-117).

*“The issues with these credit card data loggers is the people who receive them don’t recognise the value of them ok. Because they see the physical object and they don’t understand the value of the information in it so, they don’t recognise the real value of it, so they don’t treat it as an object with great value”* (Case A: 121-126).

### *Processes Perspective*

From a *Processes perspective* the issues related to *Immediate Changes* far outweighed (7) those identified as *Secondary Changes* (1). No *Preferred Changes* emerged from this level of analysis for Organisation A. This result appears to have

been driven by considerations of using active RFID technology. The participant was easily able to identify *Immediate Changes*. Because of this focus he did not appear to extend his considerations to *Secondary Changes*. It might be that because of his focus on *Immediate Changes* he saw little need to identify *Preferred Changes*.

In addition, the results from the participant's comments appeared to indicate that active RFID technology is performing well:

*"Haven't had one fine. And look some of the initial work we did was on the cooling systems at Dover in our process plant down there. We had them underwater for an hour and half and we didn't have one fail. I've bent them, I've dropped them, they are quite literally bomb proof, there are a surprising number I find that don't work straight out the box brand new ones that don't work. Which is annoying, to be perfectly honest. But once they are operational we haven't had one fail. They just are quite literally indestructible. So that's a couple meters under water so, and that, sort of minus one degree's, so it's a fair test and we've found it to be very successful"* (Case A: 186-195).

#### *Relationships to Supply Chain Partners Perspective*

In Organisation A no changes were identified as *Relationships to supply chain partners perspective*. This can be explained by the fact that the use of the technology was internal within this organisation and precluded the need for relationships with supply chain partners.

*"We use them quite a lot internally, to track products between our harvest site and here, or within our processing plants, externally use as far as the actual cold chain from here to customer, it's limited, we use them if we have a specific issue"* (Case A: 45-49).

#### *Effects Matrix: Direct, Meta and Side Effects: Organisation A*

This *Effects Matrix: Direct, Meta and Side Effects* can be found in Appendix 2.1.2. Participant A did not identify any changes that were related to the *Meta* and *Side Effects*. This evidence suggests that the overall effects of change in this organisation

tended to be direct. It was thought that the participant considered the use of active RFID technology to be a necessary part of the production and supply chain management and not a separate issue that may or may not be adopted in these processes.

In this matrix there are three major perspectives: *Application objectives*, *As seen by administrator* and *As seen by partner*. Within each of these the analysis is further divided into *Systems*, *Processes*, *Relationships* and *Performance*.

#### *Application Objectives Perspective*

From this perspective no neutral *Direct Effects* changes were identified, however, single negative and positive *Direct Effects* were revealed. This result suggests that the participant is neutral with respect to the use of the technology. It could be that this stems from his exposure to the technology and his personal experience in using it. In contrast, from a *Processes perspective* a majority of entries are in the neutral *Direct Effects* columns (4), although he did identify one negative and two positive changes. Since this participant had already employed other forms of quality control for over a decade, he did not see any real differences that could be directly attributed to the use of the technology:

*"We had a fairly good database already. We had used it for all previous work done with business for 15-18 years" (Case A: 320-321).*

*"We've used all sorts of data loggers to measure the various bits of the processes. What RFID has done is make that more accessible. So it hasn't, it probably hasn't created, it hasn't prompted any processing changes, what it has done is made it much easier to confirm that what we are doing is right and it does work" (Case A: 322-326).*

*"What we manage to do is confirm what we are doing is right, and we've been able to do it repeatedly and at low cost and fairly easily" (Case A: 328-329).*

In addition, the positive and negative *Direct Effects* identified at this level were the result of his comparison between the use of active RFID and data loggers. On this basis he was convinced that the newer technology was far more effective and beneficial than the use of the outdated and cumbersome data loggers:

*“In using the classic historical data loggers to get a data logger inside the fish is an absolute nightmare. It’s you actually have to make a large incision in fish you put it inside the belly cavity it’s not the true measure” (Case A: 172-175).*

With respect to the *Relationships* and *Performance perspectives*, no changes were identified in Organisation A. This implies that the majority of the use of time-temperature monitoring equipment was in internal processes, while the participant would like to wait to implement external processes when he has support from senior management.

#### *As Seen by Administrator Perspective*

From the position of *As seen by administrator* for *Systems perspective*, the majority of entries are in the negative *Direct Effects* column (3) while there are only single entries in the neutral and positive columns. The analysis of this portion of the matrix suggests that the use of active RFID technology was not well received by Participant A and generally it was considered to be having an adverse impact on the operation of the organisation processes as a whole. In particular, he pointed out the difficulties with numbering of the tags system and the need for extra personnel to undertake this activity, as well as the on-going software license fee. This consideration was supported by the participant:

*“We have had some issues with the accuracy of them. We actually have to, we developed, it’s not quite on the list but just the side help with some other stuff, the numbering on the system is bloody hopeless, trying to refer to, find the tag oh it’s the tag no. eea74b it’s absolutely hopeless. So we actually set out our groups of 10 and our first group is A0-A9 and our second group is B0-B9 then group C0-C9 and so it goes, and then makes it easier to refer to. But you can’t then tell the ‘Organisation RFIDS’ server that you are calling*

*that logger A 5 it will only accept and that is a bit an issue” (Case A: 201-208).*

In terms of specific examples the participant went on to say:

*“Well that is one of the things we chase ‘Organisation RFIDS’, something we can program and download and look at them on the site without going through their server. Now they [RFID service provider] are unwilling to do that because of the commercial arrangement and I actually see that and have always seen that as a weak point in their offer” (Case A: 225-229).*

No changes were identified that were related to *Processes* and *Relationships*. There was only one change from a *Performance perspective* and it was seen as a negative effect. In this the difficulty of being able to clearly demonstrate a ROI based on the adoption of active RFID technology was a key issue put forward by the participant:

*“So, the economic rationale for RFID is essential but it’s almost impossible to calculate and that’s why I’m so excited that somebody is having a hard look at how to mount that argument. Ok it is a critical issue, we’re asking to spent money, and I go to MD or whatever and I say I want to spend, even \$5,000 or 10, 50 or 100 first question is, what are we going to get back? What’s the payback? And at the moment that’s a question I can’t answer” (Case A: 377-383).*

He went on to say that the issue of ROI is very important but it is very difficult to calculate:

*“Well we need to know what the return is, and at the moment we have no measure of what the potential benefits are, it’s a question of valuing information and putting a dollar value against information and that’s very, very difficult. If we can guarantee our cold chain, will that increase sales and increase profitability? Absolutely! By how much? I’ve got no idea, and this is the very hard bit, this is where it becomes so difficult. So the important issue is, what’s our return? How to measure our return on this*

*investment? And measuring the cost the investment is very easy, measuring the return is the killer” (Case A: 398-406).*

#### *As Seen by Partner Perspective*

For all of the four perspectives within the *As seen by partner* category, no *Direct Effects* were evident in the data. This implies that the participant mainly focussed on internal processes rather than external relationships with supply chain partners.

#### ***Explanatory Effects Matrix: Organisation A***

This *Explanatory Effects Matrix* can be found in Appendix 2.1.3.

#### *System Perspective*

For Organisation A the position of *Systems* perspective show the majority of entries were in the *Description of Changes* (22), however, for *Short-term Operational*, *Mid-term Tactical* and *Long-term Strategic* a single effect was identified in each one. The results indicated that some limitations of active RFID technology are the difficulty to recover RFID tags, and the value of the RFID tag, as well as the value of data inside the tags. The RFID trials had led to few changes being associated with *Short-term Operational*, *Mid-term Tactical* and *Long-term Strategic*. In turn, this had a direct negative impact on the overall perceived effectiveness of the active RFID technology. This has been further compounded by the limitation of the technology and a lack of a ROI or pay back period to support the adoption of the technology. For example, the participant stated that:

*“I’m waiting for the new version to come out, I also want an USB card reader to come out the current card is limited” (Case A: 53-54).*

#### *Process Perspective*

With respect to Organisation A the only information identified was located in *Description of changes* (11). This can be explained in that the adoption of active RFID technology was limited. It appeared that the lack of support, interest and commitment from senior management has also had negative implications for the adoption of the technology. The participant indicated that he was becoming frustrated with the lack of finances to adopt the technology:



*“We have just spent \$2.5 million in Dover completely refurbishing that plant. We are confident in doing this because we can say cost is \$2.5 million, it slices a million dollars a year out of our costs, pay back in 2.5 years therefore the board is confident to say well yes; here’s the money because we can see an argument. In an accounting sense it works, not only that we can go back in 12 months time and say, did I do that? We expected it to slice a million dollars out, did it actually do that? With RFID you can’t do that, and this is one of the problems” (Case A: 365-373).*

### **Summary of the Three Matrices for Organisation A**

The participant in Organisation A identified the following issues:

- He was aware of the use of active RFID technology for time-temperature monitor of perishable in transport and had conducted limited trials with that technology;
- He appreciated the potential such time-temperature monitoring offered the organisation, both in terms of quality assurance during transport and also to manage the risk of loss or spoilage of food and the risk to public health of incorrect handling and storage;
- He understood that there was a need to develop a business case to financially support the adoption of time-temperature monitoring, but had taken only limited steps to formulate that business case;
- He considered that the current quality assurance measures in food processing were adequate and did not necessitate the expansion of these to cover the handling and storage of processed food during transportation; and
- He saw resistance to the introduction of active RFID technology from both logistics service providers and supply chain partners, because they feared that their operations could also be monitored.

Most notable were the positive attitudes toward active RFID technology. It appeared that the drivers of the adoption of the technology were business objectives and corporate strategies. Being interested in the use of the technology, Organisation A had begun an extensive planning process.

However, the participant identified negative aspects of active RFID technology, such as the limitation of the technology and the difficulty in determining a real ROI. In addition in his view, the technology was relatively new and supply chain partners did not see the value of the technology and also the value of the data inside RFID tags.

#### **5.1.1.2 Key Effects-outcomes from Causal Diagram**

The structure and nature of analysis and interpretation of the cause-effect matrices was presented in Section 4.3.3. The interpretation presented in this section is focussed on the outcome from Interview 1.

##### ***Interview 1***

As the result of an analysis of the three matrices with the Logistics Manager in Organisation A, a network of causal relationships was developed from the transcript data from Interview 1. This is graphically depicted in Figure 5-1. For ease of reading larger versions of the causal diagram can be found at Appendix 3.1.

As shown in Figure 5-1 for Interview 1 from Organisation A, there are 15 input factors and 9 outcomes. Within this there is a pathway that forms a link between these based on intermediate issues (A-M).

##### ***Summary of Causal Diagram: Organisation A***

From an overall perspective of the causal diagram for Organisation A some key issues were identified. The participant in Organisation A perceived that the adoption of active RFID technology had been very successful in cold chain distribution. However, the participant indicated that the lack of financial analysis and relevant economic models, and the limitations of the technology are considered to be drawbacks to the adoption of the technology. It was also noted by the participant that these impacts could either directly influence the adoption of active RFID technology or have more indirect effects that were dependent on mediating variables.

The drawbacks of the adoption of active RFID involved *Calculate and extend product shelf life (Input 1)*, *Determine cost-of up-front/manufacturing and retail*

cost of products (Input 2) and Balance retail price setting against consumer demand (Input 3) lead to Hard to calculate ROI/pay back period (A) which made the level of the Demand to implement RFID for time-temperature monitoring (B) low. The active RFID technology when adopted, proved to have substantial Internal process (C) for Monitoring environmental conditions and product core temperature (D) which was also high because the company needs to Comply with export standards (E). It was also noted that the strategic use of active RFID technology linked directly into the heart of the organisation's production line meaning that quality control, quality assurance and food regulation are assured. While the participant used active RFID technology to Monitor the temperature of consignments with their supply chain partners (F), the technology was seen as negative. However, the use of active RFID technology could serve to Reduce the number of ongoing quality issues with customers (G). The use of the technology also provided advantages to the organisation that generate a large volume of evidence with Logistics service providers along the food supply chain (H).

One of the benefits of the technology that was identified at Organisation A was its contribution to environmental outcomes in moving from Styrofoam to cardboard containers (I), as the technology can play a part in verifying the handling conditions of these containers. It was stated that the technology was considered to be particularly important to Ensure the core temperature of products were monitored (Outcome 1), Temperature of products were monitor consistently during process (Outcome 2), and Environmental factors were measured all along the cold chain (Outcome 3). Another benefit that emerged from the adoption of active RFID technology at Organisation A effectively was Understand the external factor conditions that effect to the quality of products (Outcome 4). It was stated that because the organisation understood the big picture of the cold chain management then the organisation was beginning to follow Correct handling procedures (Outcome 5).

The value of the data collected in RFID tags (Input 4) and the Recovery of the tags (Input 5) were both considered to be negative when considering the adoption of the technology on a production basis. It was also identified by the participant that Recover of RFID tags (J) is often cumbersome and the recovery of tags is not easily

achieved. Participant A recognised that *Unwilling to implement active RFID technology (Input 6)* from their supply chain participants in their distribution chains was a major barrier to the adoption of active RFID technology. As most of the supply chain participants do not see *Value of the information in RFID tags (Input 7)*. However it was considered by the participant that an alternative is having readers at both *Ends of the cold chain and having the data loggers read at the far end (Input 8)*, which is a strength of the technology.

It is apparent that while the participant interviewed in this research was *Very enthusiastic about the technology (K)*, he was waiting for *Development of new solution (Input 10, M)*. He indicated that there is a lack of business solutions to such monitoring processes that can be efficiently integrated into the processes of the supply chain partners. He also identified that the cost models associated with equipment available to cold chain logistics suppliers is frequently very expensive, often cumbersome and not easily integrated into their business operations. Frequently such equipment relies upon human operations, such as reading of data and manual *Transcription of such data to other forms or keyboards (Input 9)*. The participant considered that a reliance on such manual handling is both error prone and subject to intermittent failure due to *Human failures (L)*, such as forgetfulness. Further, the manual processes permit adjustment of such readings to favour a company staff or particular third party logistics service providers.

The participant stated that the introduction of active RFID technology has not changed any handling conditions, but confirmed that the *Current handling conditions are correct (Outcome 7)* and that *Repeatable monitoring can be performed at low cost and ease of use (Outcome 8)*. The cost associated with using active RFID technology is far less than traditional data loggers. The ability to attach RFID tags inside the products makes this technology a versatile, *Efficient and cost effective technology (Outcome 9)*. The participant also clearly mentioned the factors in the determination of *ROI of active RFID technology (Outcome 9)* were questions of the *Balance investment on RFID with capital expenditure (Input 11)*, *Value of the technology (Input 12)*, *Measurement of potential benefits (Input 13)*, *The value of the data collected by RFID (Input 14)* and *Ability to increase sales and profitability by guarantee the quality control of the organisation's cold chain (Input 15)*.

The concept of major feedback emerged as an important issue during the interview and it appeared that the *Ability to maintain the temperature (Outcome 6)* was intended to help to *Comply with food quality assurance standards (E)*. The adoption of active RFID technology had a number of positive impacts on the ongoing overall effectiveness of the processes. After experimenting with active RFID technology if the organisation can envisage a potential benefit derived from the technology, they may decide to commit more resources to develop a more strategic perspective for the use of it.

Table 5-4 shows a summary of the input factors and outcomes of the causal diagram.

**Table 5-4. A Summary of the Input Factors and Outcomes of the Causal Diagram Analysis: Organisation A**

Input Factors	Outcomes/Achievements
<ul style="list-style-type: none"> <li>• The ability to calculate and extend product shelf life</li> </ul>	<ul style="list-style-type: none"> <li>• The ability to monitor the core temperature of the products</li> </ul>
<ul style="list-style-type: none"> <li>• The need for Organisation A to determine cost against consumer demand</li> </ul>	<ul style="list-style-type: none"> <li>• The ability to monitor temperature during processing</li> </ul>
<ul style="list-style-type: none"> <li>• Value of the data collected by the tags</li> </ul>	<ul style="list-style-type: none"> <li>• The ability to monitor the environmental temperature</li> </ul>
<ul style="list-style-type: none"> <li>• Recover of the tags in short time to be useful</li> </ul>	<ul style="list-style-type: none"> <li>• Understand the external conditions effect the quality of products</li> </ul>
<ul style="list-style-type: none"> <li>• The against from transport carriers</li> </ul>	<ul style="list-style-type: none"> <li>• Guarantee correct handling procedures have been followed</li> </ul>
<ul style="list-style-type: none"> <li>• The value of the data in RFID tags</li> </ul>	<ul style="list-style-type: none"> <li>• The ability to maintain the temperature</li> </ul>
<ul style="list-style-type: none"> <li>• The ability to be able to read information at the end of cold chain</li> </ul>	<ul style="list-style-type: none"> <li>• The ability to confirm the current handling conditions are correct</li> </ul>
<ul style="list-style-type: none"> <li>• Technical problems of RFID technology</li> </ul>	<ul style="list-style-type: none"> <li>• The ability to repeat monitoring at low cost and ease of us</li> </ul>
<ul style="list-style-type: none"> <li>• Balance the investment decision on RFID with capital expenditure</li> </ul>	<ul style="list-style-type: none"> <li>• Achieve ROI on time-temperature monitoring</li> </ul>
<ul style="list-style-type: none"> <li>• The ability to estimate the value of ROI</li> </ul>	
<ul style="list-style-type: none"> <li>• Measure of potential benefits</li> </ul>	
<ul style="list-style-type: none"> <li>• Assess value of RFID technology</li> </ul>	
<ul style="list-style-type: none"> <li>• The ability to increase sales and profit</li> </ul>	

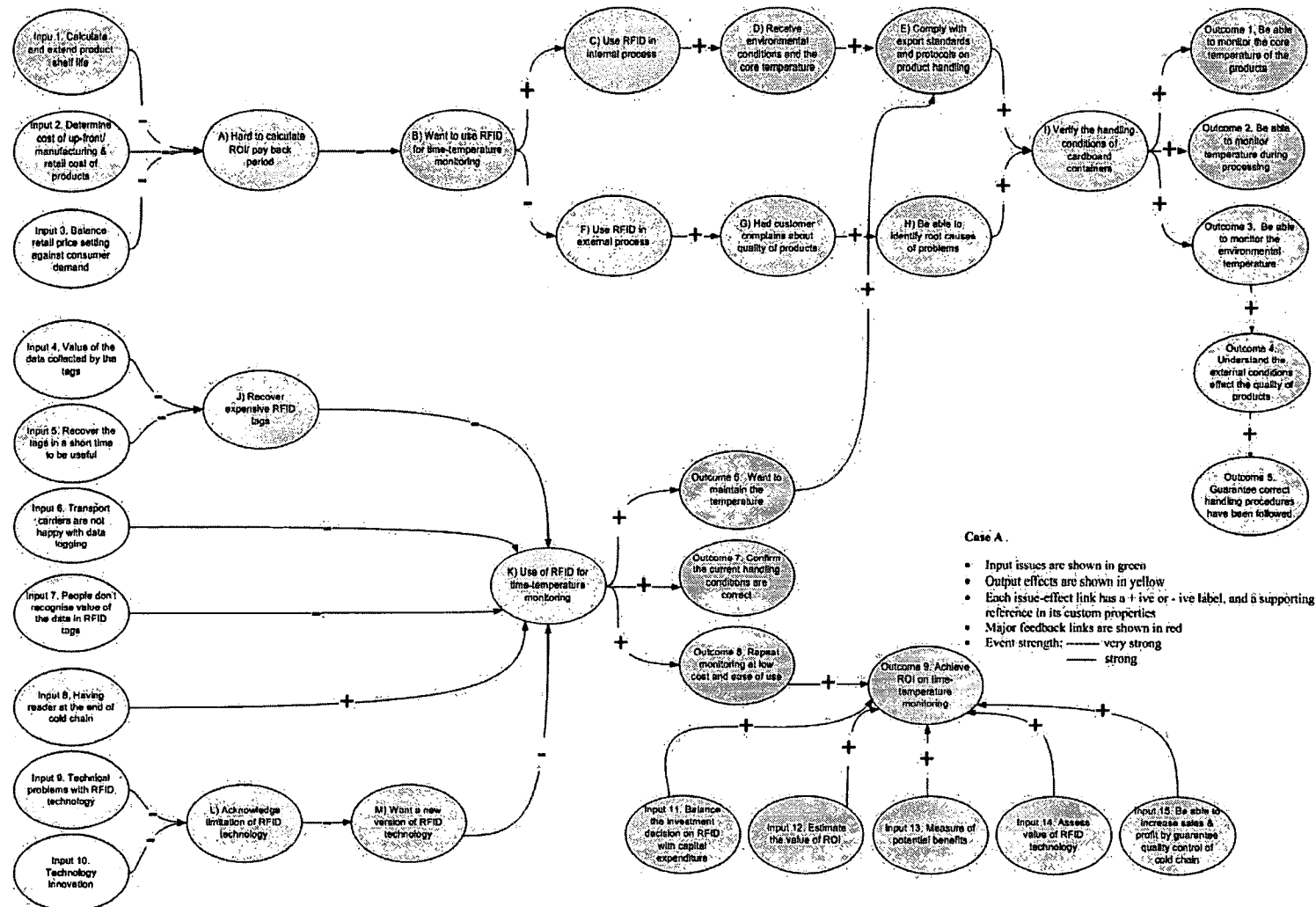


Figure 5-1. Causal Diagram: Organisation A

### **5.1.1.3 Overall Summary Findings: Organisation A**

The initial perception of the active RFID technology initiative amongst Organisation A was frustrating. This related to an on-going software fee, the numbering system, the inaccuracy of tags resulting in errors and labour intensiveness. The piloting also revealed a number of problems associated with the use of active RFID technology. In particular these involved the loss of tags, the limitations of memory and RF frequency range. While the company did not see the loss of tags as a cost issue, the loss of the information they contained was critical. Therefore the recovery of tags was a main issue for the company because of the value of the data they had collected. At the time of the pilot, first generation active RFID technology was involved that meant only limited storage of data points was possible. The company identified technical problems with the RFID tags to be as follows:

- Numbering system was not convenient, and so the organisation used their own labelling;
- Not all tags were not correctly zeroed and while some were up to 0.5 degrees out, which was an acceptable level;
- Others were found to be more than one degree out. Some tags did not work correctly;
- Accessing system to the service provider's web site was not convenient;
- The time-based cost of access to the service provider web site, when an alternative would be to purchase the tags and the right to use the software to directly read the tags;
- The tasks to set up a RFID tag to log was inconvenient;
- Similarly the user needed to login each time to read an RFID tag;
- Some tags could not be reinitialised, but kept running; and
- Some tags could not turn off.

From previous experiences with the pilot test studies with active RFID technology, the participant saw the technology as a means of more effectively doing business. From having an intensive involvement with the pilot tests the participant was preparing a business case to support the adoption of the technology. Organisation A

operated in a high risk environment where the level of risk was not only confined to internal processes but could include the external supply chain as well. While it had implemented active RFID technology for a short period of time the overall perception within the organisation was resoundingly positive and enthusiastic. However, it also should be noted that Organisation A has not done as much consignment monitoring as they would have liked.

The level of importance of ROI and payback period of active RFID technology has previously been cited in the literature as barriers to the adoption of the technology for time-temperature monitoring (Lee and Ozer, 2005). The findings within this organisation largely affirms the literature. The participant from Organisation A identified the issues associated with ROI on active RFID technology as below:

- ROI was absolutely an important issue with active RFID technology;
- The company needed to balance the investment decisions on active RFID technology with capital expenditure, development of new products and the expense of marketing campaigns;
- The up-front cost of implementation of RFID monitoring was only part of the cost;
- The intangibles associated with active RFID technology made it a more difficult investment decision;
- There was a concern of how to effectively evaluate the ROI and pay back period;
- The economic rational for active RFID technology was essential, but was impossible to calculate; and
- All questions of investment in the technology ultimately came back to estimating the extent of ROI.

Further he indicated the factors in the determination of ROI are:

- The measurement of potential benefits;
- Question of the value of the technology;
- The value of the data collected by active RFID; and



- The ability to increase sales and profitability by monitoring the quality control of the company's cold chain.

In terms of the benefits of the technology were not immediately experienced and it was seen more of a long-term benefit. Once again, due to the relatively short timeframe that the initiative had been implemented in the organisation, it was considered too early to tell whether a tangible return on investment could be expected. These findings also identified that senior management should support and drive implementation of the technology in order to better facilitate the adoption process. The most significant benefits of the technology could be achieved in businesses that integrate logistics activities directly into existing business processes. This often requires changes to internal business processes. The magnitude of these changes was dependent on how active RFID was used by the organisation. From reviewing the preceding discussion the common theme regarding ROI on active RFID technology was that it was a long-term investment and the organisation should not expect to see high level returns in the immediate future. The other aspect of ROI that was prevalent within Organisation A was the view that the benefits of ROI were experienced through more indirect means than the results that RFID delivered. The ROI for the organisation undertaking active RFID technology should be assessed through both traditional and more intangible benefits, as the intangible benefits may have follow on effects that may deliver returns through efficiency gain within other business activities.

### **5.1.2 Case B**

Organisation B is a family operated business that processes shellfish products located in Tasmania. The organisation has been trading over 5 years. It has grown significantly to integrate with large supermarkets and overseas partners. The organisation conducted some RFID pilot test with 'Organisation RFIDS'.

#### **5.1.2.1 Effect-outcome Matrices Findings**

The structure and nature of analysis and interpretation of the effect-outcome tables was presented in Section 4.3.2. Within this section the findings from the three matrices will be presented.

**Change Matrix: Organisation B**

This *Change Matrix* can be found in Appendix 2.2.1.

*Systems Perspective*

From the perspective of *Systems* in *Change Matrix* for Organisation B the majority of entries are in the *Secondary Changes* (29) column and the least number of entries are in the *Preferred Changes* (10) and *Primary Changes* (3). This implies that the overall effect of changes in *Systems* tend to be more indirect rather than direct. The *Secondary Changes* were largely practical supporting the *Preferred Changes*. For example, the changes in new food safety regulations necessitate use of chilled trucks for transporting products. This is largely because if logistics service providers did not follow the regulations, they could lose their customers:

*“The new food safety standards come in later this year and Tasmania is actually leading the way, going to be leading the pack, that’s going to prevent that from happening, they [supply chain participants] won’t be able to move their products in unchilled trucks” (Case B: 171-174).*

*“December or January is going to be all these people [supply chain participants] scrambling to find freight companies that can deliver” (Case B: 513-515).*

In addition, the higher levels of involvement with large supermarkets were thought to have a number of significant impacts on the use of active RFID technology for time-temperature monitoring:

*“It’s not going to be long before someone like a Woolworths or a Coles says for every pallet of goods delivered to our warehouse we want a chip on the pallet, I mean some of them now are receiving goods that have a little chip, radio chip that when it crosses their dock tells them what’s on the pallet. It’s not going to be long before that carries the same information, and they will monitor that before they receive the goods, and if it’s been outside a spec they just won’t accept it. That’s where it’s going ultimately I believe. I really do, and that is going to force it all back down the supply chain. That’s my understanding” (Case B: 295-303).*

It is interesting to note that the participant had a positive attitude towards active RFID technology. Some changes were reported regarding cost as a drawback of implementing the technology. This view was supported by the participant:

*“What you are prepared to invest would really boil down to what your margin is” (Case B: S355).*

*“Once a week, you would invest what, invest 50 bucks a week in each of those customers. Wouldn't you to be able to do that? I would, I am sure” (Case B: S363-364).*

*“Let's say that you are going to do it for three or four different customers at up to about 200 bucks a week, that might be a bit high” (Case B: S366-367).*

#### *Processes Perspective*

From the perspective of *Processes* issues related to *Preferred Changes* (17) were more numerous than those identified as *Immediate Changes* (6) and *Secondary Changes* (5). This is indicative that there has only been a low level of implementation of the technology within Organisation B. It was stated that the participant had been involved at the initial stage through a series of pilot tests, helping to develop an understanding of their distribution chains:

*“We've only done some very basic trials of our own. We had an arrangement with 'Organisation RFIDS' to lease some equipment and we've really only been using it in an informal manner up to this stage” (Case B: 94-96).*

*“It's new technology. We don't want our customers seeing the results at the moment, so that's why we have had them sent back, until we get comfortable with what we're doing and what the readers are doing” (Case B: 106-109).*

*“It was really just for us to have an understanding of what our own cold chain management process was doing, for us to have some idea of what the transport companies were doing and what happened once it got to the customer. That was really the reason behind it” (Case B: 116-119).*

However, this was an issue the participant also considered particularly important in the adoption of active RFID technology for time-temperature monitoring. It appeared that the technology was also seen as a facilitator to help develop a positive change in the organisation and its relationship with customers. The involvement of the technology in this respect was also thought to be helping develop an understanding of distribution chains. As the participant stated:

*"I would certainly like to do the full supply chain" (Case B: 254-255).*

*"I would like to do it as a regular thing. But, I would like to be able to say to our customers, we are going to, we are going to temperature check your delivery once a week" (Case B: S285-286).*

*"I would like to be able to say to them that we are going to be monitoring your consignment X amount of times per month" (Case B: S287-289).*

#### *Relationships to Supply Chain Partners Perspective*

For *Relationships to supply chain partners perspective*, the number of *Immediate Change* (2) issues increased between *Secondary Changes* (3) and *Preferred Changes* (4). This can be explained in that the adoption of active RFID technology resulted in *Immediate Changes* which had an effect of influencing *Secondary Changes* and *Preferred Changes*. This ability to review that the technology was expected to foster a greater sense of empowerment among the participants and be a useful tool for time-temperature monitoring to lead further improvements in the organisation in the future. Below are examples of an *Immediate Change*, *Secondary Change* and *Preferred Change*.

The following quotations illustrate these changes. The *Immediate Change* has effect on influencing *Secondary* and *Preferred Changes*:

*"Most of the carriers we deal with say they're quality assured, but there's no guarantee they're monitoring it properly" (Case B: 215-216).*

From the *Immediate Change* a *Secondary Change* it was revealed:

*“Half the time, they don't use them. The time will come with the changes to food standards is going to mean that they are going to have to have chilled trucks” (Case B: S250-252).*

As a consequence of the *Immediate* and *Secondary Changes* a *Preferred Change* was identified:

*“Which is one of the reasons we would like to drive, drive, the monitoring ourselves” (Case B: 217-218).*

In addition, it was thought that there had been a considerable positive attitude towards active RFID technology since the involvement with large supermarkets as the participant stated:

*“The people that we did those few trials with just welcomed it with open arms, because they are dealing with Woolworths and Coles who are saying they want this information, and they've got someone .....a supplier, instead of being told you have to do this is actually wanting to do it. They were thrilled” (Case B: 279-283).*

According to the Diffusion of Innovation theory , Woolworths and Coles can be regarded as widely respected “early adopters” that in turn drive a wave of subsequent adoption by more conservative organisations.

#### ***Effects Matrix: Direct, Meta and Side Effects: Organisation B***

This *Effects Matrix: Direct, Meta and Side Effects* can be found in Appendix 2.2.2.

No changes were identified that related to the relationship with all *Side Effects*. It implies that the participant considered the RFID technology to be more to do with *Direct Effects* and *Meta Effects* rather than *Side Effects*. It would appear that changes in the relationship with large supermarkets and the introduction of new food safety standards were the key drivers for the changes in *Meta Effects*.

In this matrix there are three major perspectives: *Application objectives*, *Seen by administrator* and *As seen by partners*. Within the analysis each is further divided into *Systems*, *Processes*, *Relationships* and *Performance*.

#### *Application Objectives Perspective*

From the perspective of *Application objectives* no changes were identified. It would appear that the adoption of active RFID technology for time-temperature monitoring was an initial stage. The participant needs time to gain a better understanding of the technology.

#### *As Seen by Administrator Perspective*

From the position of *As seen by administrator perspective* for *System* the majority of equal entries are in the positive *Direct* and *Meta Effects* (9 each) and the least number of entries are in the negative *Direct Effects* (5), and negative *Meta Effects* (5). The positive *Direct and Meta Effects* showed that the participant was generally more interested in active RFID technology and was keen to be involved with it. Consequently, it was thought that there was an active RFID technology awareness developing throughout the organisation. As the participant stated:

*“In fact I’m at the moment about to sign up, I’ve got to work out if I sign up for three months contract or a year’s contract or whatever and I want to talk to our factory manager about that because, pending on how many he wants to do and how he wants to utilise it” (Case B: 369-372).*

The change in *Systems* was thought to be having a positive impact on the effectiveness of the organisation. This implies the participant was more positive about the uptake of the technology and as a result more prepared to implement it. Active RFID technology was working as a tool to pinpoint the cause of problems and to enable the organisation to receive real time information on environmental factors such as temperature, humidity and shock.

*“Use the technology to assure as it could prove the carrier” (Case B: 287-291).*

Because of the lack of industry standards, Organisation B is developing their own standards and intends to apply these throughout their cold chain.

*“Our company sets the benchmark in this country for oyster processing and handling by a mile” (Case B: 437-439).*

In addition, the positive attitude towards active RFID technology and closer relationship with large supermarkets were considered important spin-offs from the adoption of the technology. Because of this the organisation is keen to use active RFID technology to support their daily activities and increase the quality assurance of products. As the participant stated:

*“The level of interest [in RFID technology] has probably increased” (Case B: S278).*

*“We would still very much love to do it and on a regular basis” (Case B: S281).*

*“If you put that system in place maybe we could, and maybe add those two extra days of shelf life from eight to ten. And also I think it is a sleep easy policy too. Because you can verify your cold chain. Then all of us get out of it is like an insurance policy” (Case B: S412-415).*

Changes in *Processes* had been far more numerous positive *Direct Effects* (12) than in positive *Meta Effects* (2). The participant also identified an equal number of changes in both negative and neutral *Direct Effects* (2 each). As a consequence of the high level of positive changes in *Direct Effects* it is evident that there has been a strong commitment to the adoption of active RFID technology as the participant stated:

*“I would certainly like to do the full supply chain. What I would love to do is even see it go to the kitchen, but a chef wouldn’t like that too much and you probably wouldn’t get your reader back, your card back, but that would be the ideal” (Case B: 263-267).*

Having high levels of senior management participant commitment has also resulted in an overall commitment to providing access to monitor the distribution chain. This commitment to using active RFID technology has resulted in general improvements in the flow of the activities in the organisation with more transparency being returned to their customers and similarly has been crucial in helping develop customer relationships:

*"We will put a reader in Sydney, and they can read themselves. Well, I wasn't real keen on it to start with. But I think we could print out and fax it to them; it could be part of our customer service. You know, once a week, you will get last week's consignment, the curve faxed to you. Particularly when we are dealing with Woolworths, it becomes part of our quality assurance that we are documenting" (Case B: S293-297).*

*"Run with the consignment and sign at that point, so then will have access to an electronic consignment note and the attached to the electronic consignment note is a temperature curve" (Case B: S300-302).*

In addition, it was clear from the participant's comments in the *Direct Effects* that the participant appeared to have an enthusiastic attitude toward the technology. These considerations were supported by the participant who stated:

*"I have some more coming from 'Organisation RFIDS', have a great deal more which means I could follow it all the way from the farm" (Case B: 257-258).*

*"Follow it all the way through that would be a very interesting exercise to do" (Case B: 260-261).*

*"Using perhaps two different types, one for monitoring consignments, but another one perhaps to use RFID internally in the factory as an ongoing monitoring and alarm system" (Case B: 384-386).*

Changes in *Relationship* show that there are few equal changes for negative, neutral and positive *Direct Effects* as well as neutral *Meta Effects* (1 each). However there



are more changes in negative (2) and positive (3) *Meta Effects*. This implies that no commitments led to low priorities being associated on the use of the technology with supply chain participants. In addition, it would appear that Participant B is more likely to have an ultimate vision as to what the information gained through active RFID technology was aiming to achieve. At the same time he also remains very focussed and pragmatic in terms of internal rather than external activities with their customers. For example the participant stated:

*"We are being a little bit selfish in some ways. We are not telling a lot of our customers, we're not saying we want you to have the reading equipment, so we are not utilising all the technology where we can give them the readers"* (Case B: 462-465).

*"We want to have that information to ourselves for a little while before we can decide how best to use it"* (Case B: 468-469).

The results of having the high level of interest in the adoption of the technology in positive *Meta Effects* was encouraged from supply chain partners. This consideration was supported by the participant who stated:

*"I see that freight companies are the ones who have got to embrace it, the freight company that says we gonna embrace this type of technology. The way I think it needs to work is, the truck needs to have sensors inside it, talking to a sensor, probably in the cab or something, but as it drives through each depot, it automatically sends that information"* (Case B: 405-410).

*"The customers embrace it first, in a proactive sense, but I'm sorry, processors that embrace it proactively will have the edge over their competitors. That's where the return is going to be. Start in front of the competitor who is not prepared to do it"* (Case B: 431-434).

No changes were identified that were related to *Performance*. This implies that the adoption of the technology within this organisation is still in an initial trial and error

stage. It appeared that it was too early to expect any comments as the participant stated:

*"We've only done some very basic trials of our own. We had an arrangement with 'Organisation RFIDS' to lease some equipment and we've really only been using it in an informal manner up to this stage" (Case B: 94-96).*

*"We haven't, I mean, we haven't invested a lot of money in this yet, it's only cost us four or five hundred dollars to get ourselves up and going to this point, you know. I would have to say that, that's money very well spent, I mean it's so easy to use" (Case B: 366-368).*

#### *As Seen by Partner Perspective*

With respect to Organisation B no changes were identified at the *As seen by partner perspective*. This can be explained in that the use of active RFID technology was internal within this organisation and so precluded a need for relationships with supply chain partners.

#### ***Explanatory Effects Matrix: Organisation B***

This *Explanatory Effects Matrix* can be found in Appendix 2.2.3.

#### *System Perspective*

In Organisation B the use of 'Organisation RFIDS's system was considered to be having a more important role in developing *Mid-term Tactical* (10) than supporting the changes in *Description of Changes* (9) and *Long-term Strategic* (5). However, the participant did not identify any changes related to *Short-term Operational*. It implies that the adoption of active RFID technology is relatively new and the participant needed time to appreciate and understand the new technology. However, it appeared that the trend of the attitude of the participant was positive toward the technology. As the participant stated:

*"We haven't, the level of interest certainly hasn't changed. If anything I think, as time goes on it is more important that we try and grab hold of it and do it from that point of view" (Case B: S269-270).*

In addition, there had been positive changes toward active RFID technology and it was thought that this was largely due to supply chain partners as the participant stated:

*“The freight company that says I’m prepared to give my customer that information, mainly in their consignments, you know, if they’ve got a consignment, the technology is there to do it that is my understanding. If someone like Westgate came to me and said we are going to give you access to that, to me says that they are very confident in their ability to maintain their cold chain, and I believe companies like Coles and Woolworths are going to demand that from freight providers” (Case B: 412-419).*

#### *Process Perspective*

From the *Process: temperature monitoring perspective*, the majority of entries were more related to *Mid-term Tactical* (8) than *Description of Changes* (5). It is interesting to note that Participant B provided mixed views regarding both negative (internal) and positive (external) attitudes towards active RFID technology for time-temperature monitoring as a quality assurance tool. The reason behind this comment was the organisation already has a very good quality assurance standard and therefore, the participant did not see any changes. For example when the participant was asked *“To what extent, and how did the use of active RFID technology contribute to the goal of meeting those quality assurance standards?”* The participant replied:

*“I’m not sure how much influence we have over that, but , in the same thing to apply that all the way through, to replace, really, so...Again number nine [see Appendix 1.1], because this isn’t really, we haven’t really used it as a, a formal tool as part of our quality assurance program, that’s probably not relevant, um, and we really haven’t, there hasn’t been any outcomes, we haven’t changed anything necessarily, as a result of what we did, cause we have got pretty good results, to be honest, so we haven’t necessarily changed anything as a result of those outcomes” (Case B: 317-324).*

In addition, it seems that the need for monitoring temperature all along the supply chain (external) is considered an important issue that needs much further investigation because of the risk of product degradation and financial loss. It was perceived that this approach had helped develop a positive attitude on the part of the participant towards active RFID technology.

### ***Summary of the Three Matrices for Organisation B***

The participant in Organisation B identified the following issues:

- Although he had a limited trial of the use of active RFID technology for time-temperature monitoring of seafood during transportation, he did not see an immediate need to adopt such technology;
- The expected cost was not significant, being perceived as mainly the cost of the monitoring equipment;
- Any change in quality assurance of food during transportation was likely to be driven by large retailers or by government regulations, rather than by a food processor and supplier;
- Demand from consumers could become a significant factor to adapt the technology, in that supply chain re-engineering should be conducted from the market back through the chain in order to achieve and sustain a competitive advantage; and
- While protection of information gained from time-temperature monitoring from competitors and supply chain partners was a priority, the possibility of sharing such information with consumers was seen as a positive potential outcome of the adoption of this technology.

These three matrices imply that the introduction of active RFID technology for time-temperature monitoring resulted in a number of benefits. The organisation was now aligned with current business policy in focusing on the importance of monitoring time-temperature outcome for food safety. The adoption of the technology had led to an increase in the ability to obtain real time information. This means that the quality assurance of products had increased and extended the product shelf life.

Mixed views were expressed about the adoption of the technology but generally a majority comments by the participant were positive and enthusiastic about the adoption of the technology. The participant viewed that the adoption of the technology can support methods to perform more effective supply chain management, which in turn can help to address food safety issues. The requirement from supply chain participants, relationships with large supermarkets and an overseas customer were the most important drivers to encourage the organisation to implement active RFID technology for time-temperature monitoring.

#### **5.1.2.2 Key Effect-outcomes from Causal Diagrams**

The structure and nature of analysis and interpretation of the cause-effect tables was presented in Section 4.3.3. The interpretations presented in this section are focussed on three causal diagrams developed for Organisation B based on Interview 1, Interview 2 and then a combination of the two interviews.

##### ***Interview 1***

As the result of an analysis of the three matrices with the General Manager in Organisation B a network of causal relationships was developed using the transcript data from Interview 1. This is graphically depicted in Figure 5-2. For ease of reading larger versions of the causal diagram can be found at Appendix 3.2.

As shown in Figure 5-2 from the causal diagram for Organisation B, there are 9 input factors and 3 outcomes. Within this there is a pathway that forms a link between these based on intermediate issues (A-R).

##### ***Summary of Causal Diagram: Organisation B (Interview 1)***

From an overall perspective of the causal diagram for Organisation B some key issues were identified. The participant agreed that there had been little change as a result of the implementation of the active RFID technology. However significant drivers behind the adoption of the technology were a closer relationship with supermarkets and overseas customers, cost of technology and new food safety standards.

It can be seen from Figure 5-2 that the experience of adoption of active RFID technology has been mixed for Organisation B. With regard to the ability to *Understand the cold chain management (Input 1)*, *Relationship with supermarkets (Input 3)* and *Process embrace technology (Input 4)*, were considered by the participant to have a positive impact on *The use of active RFID technology (A)*. In contrast, the *Limitation of the active RFID technology (Input 2)* had a negative impact on *The use of active RFID technology (A)*. The most common factors that were referred to by the participant as influencing the effectiveness of the use of the technology were the *Ability to monitor the whole supply chain (B)*, *Pinpoint cause of problems (C)*, *Monitor location for tracking the movements of goods (D)*, *Monitor temperature for QA of safe food handling (E)* and *Increase ability to claim on insurance (F)*.

The overall success of the five intermediate issues generated from the adoption of active RFID technology indicated a level of the ability to *Reduce failure rate (Outcome 1)* and *Extend product shelf life (Outcome 2)*. A focus on quality control and assurance of products for customers in Japan translated into a perceived need to employ the technology that would provide shelf life testing of exported products. It is interesting to note that this organisation seems to be only one in the aquaculture industry that has provided shelf life monitoring.

The participant in interview B-1 indicated that the temperature and location monitoring were two separate issues. First, temperature monitoring was for quality assurance of safe food handling and location monitoring was for tracking the movement of goods, for locating failures in time and place. It was agreed that the supply chain of products are very *Long supply chain (Input 5)* with a lot of risks and problems with carriers who *Fail to handle the product properly (G)*. Quality control is very difficult as carriers can say that they have upheld quality assurance but there can be no guarantee that they did handle the goods correctly. Therefore the organisation would like to monitor the transportation process for their *Own quality assurance (I)*.

It was also stated that they *Do not want to share the result of temperature curves with their supply chain partners (H)* as they will wait until they *Feel confidence*

with the technology (J). It was noted by the participant that the organisation would like to have sufficient *Quality assurance processes in place* (K) so that the results can be published to customers. It was thought that this would have two positive effects for the organisation as a whole. Firstly, the ability to improve quality of the products and secondly the ability to provide customers with a market advantage.

The participant from Organisation B was not aware of any industry-based or national pressure to improve quality assurance through RFID monitoring. However, there was support of active RFID technology from large supermarkets and retailers. Three main critical success factors that were referred to as influencing the effectiveness of the adoption of active RFID technology were *Demand from large supermarkets* (Input 7), *New food safety standards* (Input 8) and *Demand from freight companies* (Input 9). The participant expected large supermarkets to require active RFID monitoring at the pallet level so that they could *Reject consignments that are outside the temperature handling specifications* (N). The participant saw no *Resistance from third party logistics* (M) as they had welcomed the use of RFID monitoring.

New food safety standards were considered to have a direct positive impact on the overall perceived effectiveness of the adoption of the technology. For seafood these have been in force since January 2006, and require that *Products be carried only on chilled trucks* (Q). Consequently, the new food safety standards appear to have been reasonably effectively to *Drive freight companies to adopt better monitoring equipment* (R).

Active RFID technology for time-temperature monitoring was perceived to be reasonably effective by the participant in interview B-1. It was considered to be performing well *In terms of the money that Organisation B has spent* (Input 6). The cost of active RFID technology was not an issue with Organisation B as the participant stated that the loss of a few RFID tags at \$15-\$20 each was not seen as a problem (Outcome 3). The participant was interested in using radio-based monitoring of chillers to *Provide real-time feedback on the temperature of containers* (O). In the view of the participant two types of monitoring would be useful. Firstly, by monitoring of consignments at the container level, using radio-

based data loggers and secondly, monitoring of products internally during *Processing using RFID to detect failures in handling conditions (P)*.

In terms of *Both extend products shelf life (Outcome 2)* and *Improve quality of the end product (L)* the participant agreed that these had been major feedback and so these play critical role in the adoption of active RFID technology.



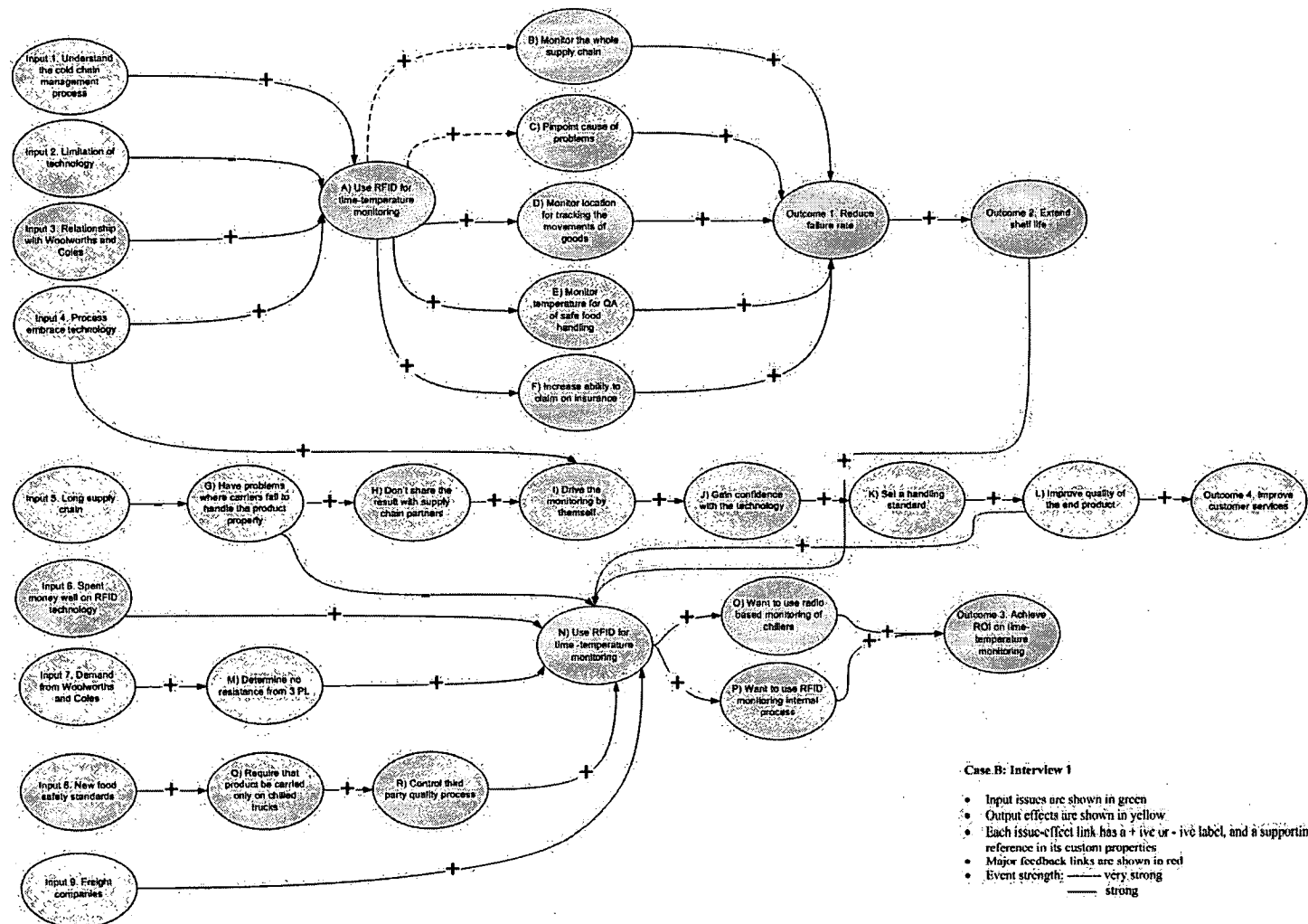


Figure 5-2. Causal Diagram: Organisation B (Interview 1)

**Interview 2**

As the result of an analysis of the three matrices with the General Manager and Factory Manager in Organisation B a network of causal relationships was developed using the transcript data from Interview 2. This is graphically depicted in Figure 5-3. For ease of reading larger versions of the causal diagram can be found at Appendix 3.3.

As shown in Figure 5-3 for Interview 2 from Organisation B, there are 6 input factors and 4 outcomes. Within these there is a pathway that form a link between these based on intermediate issues (A-M).

***Summary of Causal Diagram: Organisation B (Interview 2)***

From an overall perspective of the causal diagram for Organisation B interview round 2 some key issues were identified. The participants perceived that RFID monitoring has been shelved as low priority while the business grows as the recording capability of the technology is addressed.

*Changes in relationship with large supermarkets (Input 1)* had been largely practical in supporting the adoption of active RFID technology. For example, the *Changes in direct supply to supermarkets (A)* and *Delivery products directly to supermarkets' warehouses (B)* were considered to have a positive impact on the *Level of interested in active RFID technology (C)*. This is mainly because a closer relationship with large supermarkets has required the ability to conduct quality assurance and risk management all along the supply food chain. Consequently, these changes in working practices were expected to help extend product shelf life and thereby create the ability to *Improve quality assurance (Outcome 1)*. A further impact that was identified by the participant resulting from the changes in the *Ability of active RFID technology (Input 2)* was greater empowerment for *Developing temperature curve to customers (D)* and *Monitor temperature regularly (G)*. The positive *Change in the temperature curve (D)* was also thought to have a positive impact on *Historical temperature data (E)*.

The introduction of the historical temperature data meant that Organisation B could *Validate the cold chain (F)*, *Reduce product recall (Outcome 2)* and *Improve*

*customer service (Outcome 4). The Ability to reduce product recall (Outcome 2) was thought to have a number of significant impacts on the Ability to reduce insurance premium (Outcome 3). Change in Monitor temperature regularly (G) caused Extra expenditure to customer (H). The participant viewed that some customers will be Willing to pay the higher price (I) but other customers May not be willing to pay (J). As the participant felt that this extra expenditure was one part of Marketing budget (K) and it would bring Marketing advantage to their customers (L). It was felt by the participant that the Limitation of the active RFID technology (Inputs 3 to 5) had led to a low priority being the Adoption of active RFID technology (M). There was a general feeling of disinterest towards the technology in Organisation B with it being viewed as an “old generation”. This negative impact has been further compounded by a Lack of ROI/pay back period (Input 6) to support the use of the technology.*

Finally, the ability to *Improve customer service (Outcome 4)* was the major feedback links back to the *Adoption of the active RFID technology (M)*.

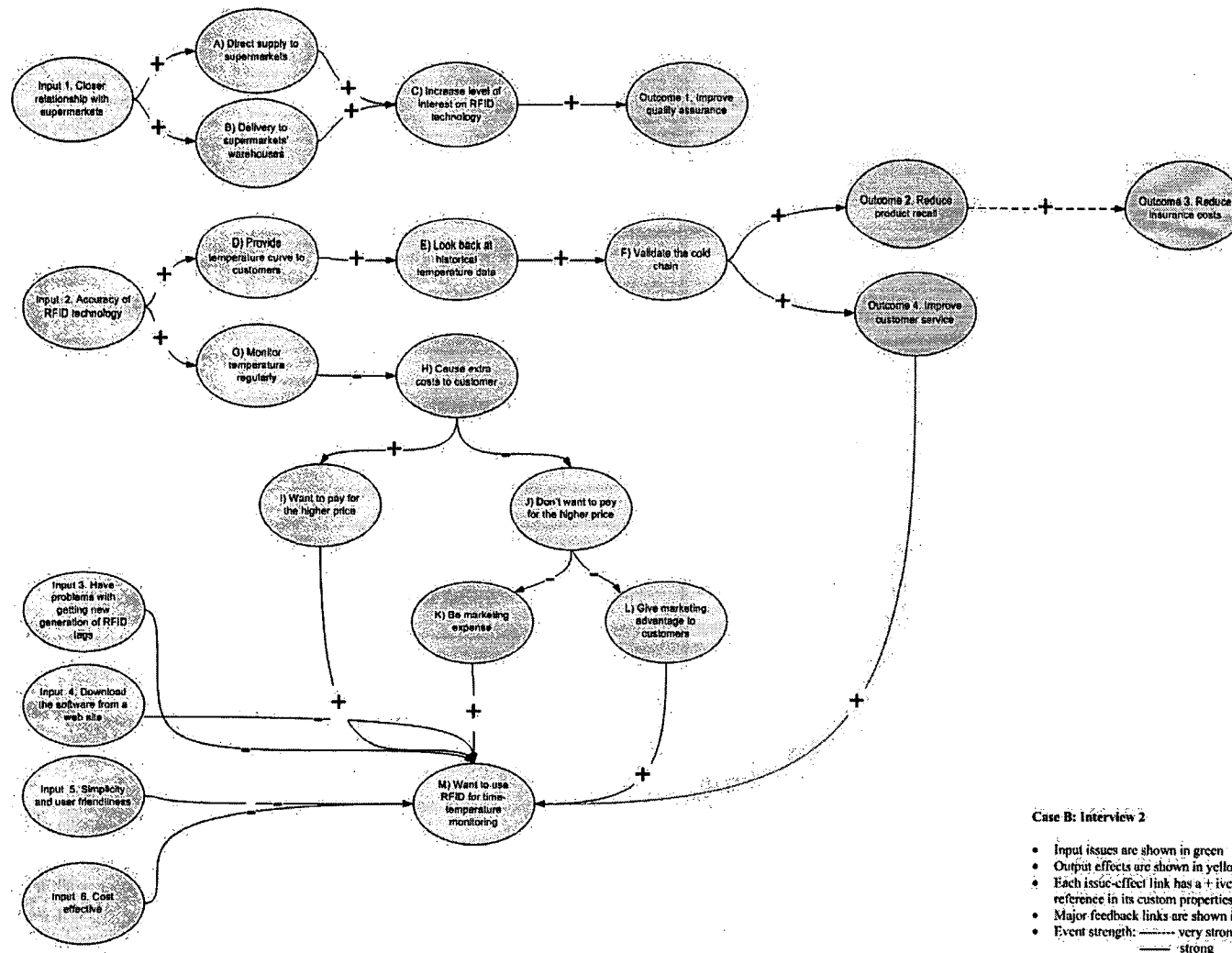


Figure 5-3. Causal Diagram: Organisation B (Interview 2)

### ***A Combination of Interviews 1 and 2***

In the introduction to this section it was established that a third causal diagram was constructed based on a combination of the data from Interviews 1 and 2. The method of doing this was established in Section 5.1. The aim of so doing was to reduce overlap in the models by producing a summary causal diagram to facilitate the formulation of explanation. For ease of reading larger versions of the causal diagram can be found at Appendix 3.4.

It can be seen from Figure 5-4 for Organisation B that the introduction of active RFID for time-temperature monitoring at this organisation is considered by the participant to have had both positive and negative impacts on the organisation. These have influenced the overall perceived effectiveness of supply chain management. The participant in interview B-2 was more consistent in his views towards changes in *the adoption of the technology (A)*. Overall, it appeared that there had been considerable improvements in the level of interest in the technology since the *Introduction of new food safety standards (Input 5)*, also *Demand and closer relationship with large supermarkets (Input 3)* was introduced. In addition, the ability to *Understand the cold chain management (Input 1)* and the *Reliability of RFID technology (Input 4)* have resulted in the adoption of the technology as one of a key elements for making the cold chain more successful. However, the participant considered the *Limitation of the technology (Input 2)* was a drawback in the adoption of the technology.

From the adoption of *Active RFID technology for time-temperature monitoring (A)* there was a greater ability to *Pinpoint cause of problems (B)*, *Monitor the whole supply chain (C)* and *Reduce cost of operation (D)*. Following on from this it was thought that these improvements (intermediate issues B, C and D) were helping to *Improve quality assurance of products (Outcome 1)*, *Reduce insurance costs (Outcome 2)*, *Achieve ROI (Outcome 3)* and *Improve customer services (Outcome 4)*. In addition, the participant indicated that the *Supply chain of products is considerably long (Input 6)* and it created considerable *Risk during the transportation of products (E)*. To counter this *Set their own standards (F)* would mean that *Quality assurance of products would be improved (G)*. This looped back to *Use RFID for time-temperature monitoring (A)*.

Table 5-5 shows the summary of input factors and outcomes.

**Table 5-5. A Summary of the Input Factors and Outcomes of the Causal Diagram Analysis: Organisation B**

Input Factors	Outcomes/Achievements
<ul style="list-style-type: none"><li>• Understand cold chain management</li></ul>	<ul style="list-style-type: none"><li>• Improve quality assurance of products</li></ul>
<ul style="list-style-type: none"><li>• Limitation of RFID technology</li></ul>	<ul style="list-style-type: none"><li>• Reduce insurance costs</li></ul>
<ul style="list-style-type: none"><li>• Demand and relationship with retailers</li></ul>	<ul style="list-style-type: none"><li>• Achieve ROI</li></ul>
<ul style="list-style-type: none"><li>• Accuracy of RFID technology</li></ul>	<ul style="list-style-type: none"><li>• Improve customer services</li></ul>
<ul style="list-style-type: none"><li>• Food safety standards</li></ul>	
<ul style="list-style-type: none"><li>• Duration of transportation</li></ul>	

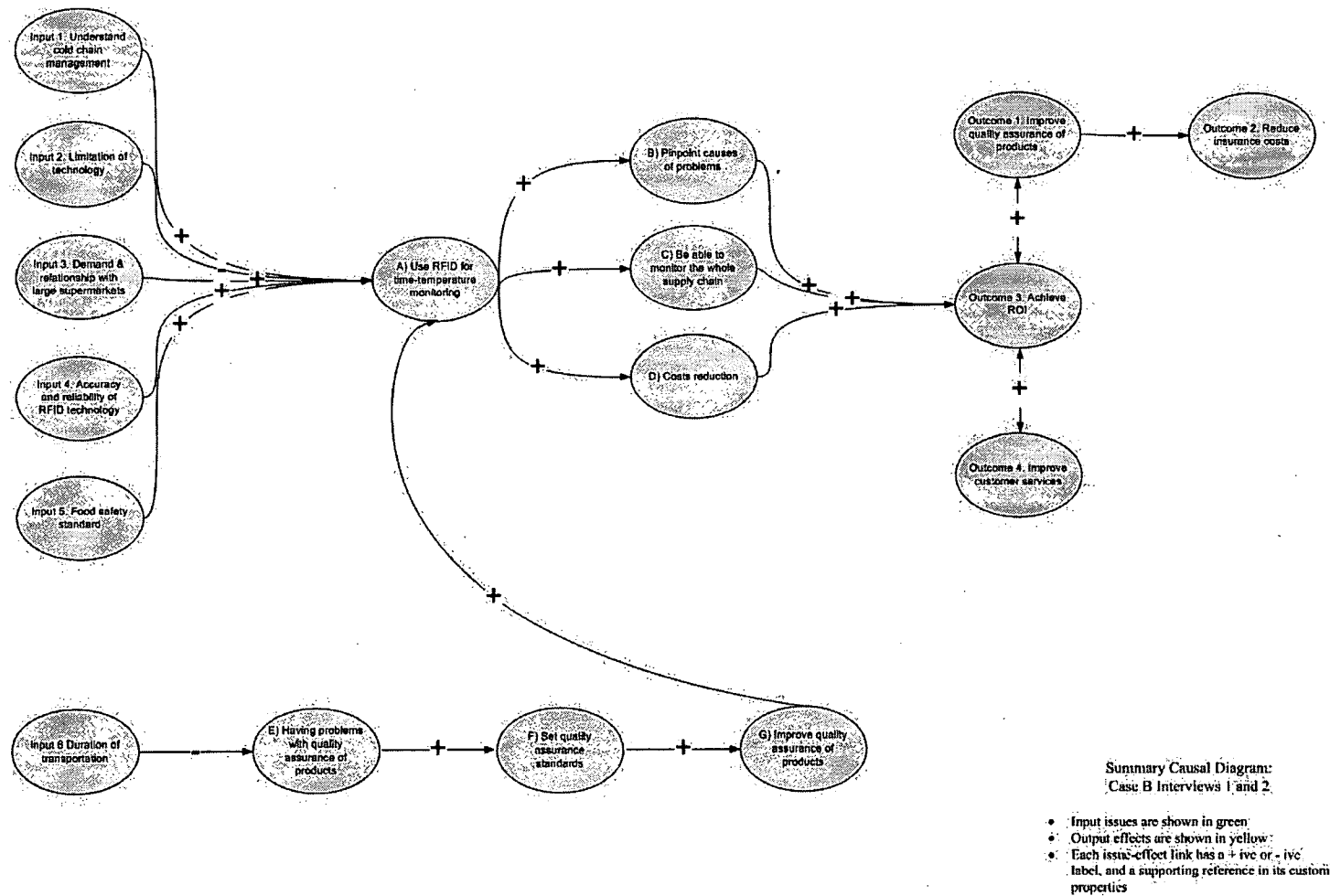


Figure 5-4. A Combination of Causal Diagram: Organisation B (Interviews 1 and 2)

### **5.1.2.3 Overall Summary Findings: Organisation B**

Organisation B provides an example of a family business utilising active RFID technology for time-temperature monitoring. The participants expressed their business' strong emphasis on high quality niche products and the use of intellectual property invested in freezing techniques to assist them to be a market leader of seafood products. The business has extended their processing to plants to mainland Australia. In the seafood industry Organisation B is the only organisation observed by this study that has any interest in active RFID technology. The organisation would like to drive food safety standards by themselves as they are aware the supply chain of their products is very long and subject to high risks partly due to problems with carriers who fail to handle the product properly.

The analysis of Organisation B showed that the strategic use of active RFID technology to specifically gain competitive advantage over competitors proved a major incentive to implement the technology. It could provide the organisation with a competitive advantage in a number of ways. This included maintaining a high quality of products for consumers by ensuring suitable environmental factors. Another key business objective that the participant saw the technology as facilitating was the continual growth of their business. In addition it was seen as another means of increasing their relationship with retailers. However, Organisation B already was a market leader within the Tasmanian market and had a considerable market-share within Australia. Apart from competitive pressures the adoption of active RFID technology was also driven by a desire to progress the business through growth and efficiency gains.

Organisation B experienced some barriers to quality control all along the cold chain with supply chain participants. Despite carriers stating that they were quality assured, this was not a guarantee that they were handling the goods correctly and that consignments were being adequately monitored. Therefore, the company would like to monitor product transportation for their own quality assurance. The company was not aware of any industry-based or national pressure to improve quality assurance through active RFID monitoring. Even though it was a key environmental issue for the company. In Organisation B temperature and location monitoring was



seen as two separate issues. Temperature monitoring was used for quality assurance of safe food handling and location monitoring was used for tracking the movement of goods and locating failures in time and place. The company was interested in using radio-based monitoring of chillers to provide real-time feedback on the temperature of containers. However it should be noted that the company had used data loggers for cold chain monitoring in the recent past.

The company would like to have a production process in which a fixed percentage of consignments were monitored by active RFID technology. Also, they would like to have sufficient quality assurance processes in place so that the results could be shown to the customers. Participant B agreed that producers had not adopted a quality assurance mentality of statistical monitoring of goods handling and adopting continuous improvement. The company had set up the drivers for better quality assurance of safe food handling in order to:

- Improve the quality of the end product; and
- Provide the producer with a market advantage.

The organisation had very little experience with wireless technologies for quality assurance monitoring. Active RFID technology monitoring had been shelved as low priority while the company grows. Therefore, the company did not invest much money in active RFID technology, but the little that had been regarded as well spent. The organisation had the experience of conducting a trial with an interstate RFID service provider ('Organisation RFIDS') that was run informally for internal purposes. The aim of the trial was to understand the application of active RFID during cold chain management. The result of the trial tended to be kept within the organisation until it felt comfortable with the technology. Having already moved to the position of a market leader, the organisation did not require significant change from the trial. The overall perception within the organisation regarding their active RFID pilot test was resoundingly positive, it was well adopted and integrated into the business activities. However, the technical limitations of the technology was seen as a barrier to the adoption of the technology; therefore the company was waiting for the next generation of active RFID technology.

The organisation indicated the critical success factors for the adoption of active RFID technology for time-temperature monitoring are:

- Freight companies needed to embrace this technology and provide real time monitoring of consignments;
- Relationship with customers;
- Supermarkets were going to demand this form of monitoring; and
- Features of the active RFID technology such as user friendly.

The use of active RFID technology provided alternative cost savings including insurance and quality assurance cost savings. The cost of RFID tags was not considered to be an important factor. However the participant saw the cost of losing the information on RFID tags is higher than cost of RFID tags.

### 5.1.3 Case C

Organisation C is one of the biggest exporters of aquaculture products from Tasmania. The organisation is located in a business area of Melbourne. Due to the size of the business and the nature of the industry they operated in, the use of time-temperature monitoring equipment did not require implementation. That is the focus of the organisation was the export of live products so there was no need to monitor environmental factors. Because of this technology adoption was not an issue within this organisation.

#### 5.1.3.1 Effect-outcome Matrices Findings

The structure and nature of analysis and interpretation of the effect-outcome tables was presented in Section 4.3.2. Within this section the findings from the three matrices will be presented.

##### *Change Matrix: Organisation C*

This *Change Matrix* can be found in Appendix 2.3.1.

No changes were identified that were related to *Preferred Changes*. This result shows that there was a lack of interest and commitment in time-temperature monitoring equipment. It became clear that the participant was focussed on the improvement of survival rate at the end of supply chain, rather than the quality assurance of these products throughout the chain:

*“The main issue we take a tag can be tough, can be improved the quality but better the tag can help us to improve the quality, even the tag tells us, hey the temperature above is higher, or the temperature in the box is no different one or two degrees when you pick them out what is the reason we still don’t know” (Case C: 68-71).*

*“The most important issue is to improve survival rate” (Case C: S5).*

*“The data logger/RFID technology aren’t critical equipments in live seafood industries. As none in the industry says that they will use data logger/RFID technology in very shipment” (Case C: S6-7).*

This attitude has been further compounded by a lack of financial resources to support the operation of time-temperature monitoring equipment. The lack of technical background also had negative implications for the development of the technology in Organisation C.

#### *Systems Perspective*

From the perspective of *Systems* issues related to *Immediate Changes* far outweighed (7) those identified as *Secondary Changes* (2). This can be explained in that the use of time-temperature monitoring equipment tends to be direct rather than indirect. This implies that the participant had a negative attitude towards the technology although the researcher had attempted to show its advantages. However it was concluded that these attempts had been unsuccessful. Below are the conversations between the researcher and the participant:

*Researcher: So, if we went to talk to XXX about running the full monitoring cycle. Is it better for you?*

In this quotation XXX has been used to refer on anonymity to an industry consultant.

*Case C: "Well to help me to understand a bit but it doesn't really mean it can improve" (Case C: 100-102).*

Consequently, it was thought that negative attitudes on the part of the participant had created a barrier to the adoption of time-temperature monitoring equipment. One of the reasons behind this lack of interest in the technology, related to the cost of the technology. The effect of high infrastructure costs was thought to be a direct cause of the low level of perceived system effectiveness associated with the use of the technology.

#### *Processes Perspective*

From the perspective of *Processes* issues the number of *Secondary Changes* (18) were far larger than for *Immediate Changes* (5). This suggests that external factors

such as seasons, supply chain partners and nature of products are regarded as key issues to control the quality of products. As the participant stated:

*"You have got to be very careful about the nature of the product you end up with particular products in summer time they are weak and they are not strong enough for the trip so what can we do? We can't do anything because it's nature, and so what can you do, no one can do anything. All research all work everything for nothing, you have got to very careful on that" (Case C: 170-174).*

The results also indicated that the participant was undecided whether the implementation of time-temperature monitoring equipment had resulted in any improvements in the quality of products. They were of the view that the technology had very little effect in improving survival rate. For example:

*"Monitoring of reliability of shipment can't prove that will it improve the survival rate or not" (Case C: S8-9).*

Consequently, it is not surprising that Participant C perceived a low level of *Immediate Changes*.

#### *Relationships to Supply Chain Partners Perspective*

From the perspective of *Relationships to supply chain partners*, the majority of entries are in the *Secondary Changes* (4) and the least number of entries are in the *Immediate Changes* (2). This implies that the quality of handling of supply chain partners plays the important role within this organisation as the participant stated:

*"The fishermen handling are very important too" (Case C: 43-44).*

In addition, from a second round interview the participant showed even less interest in time-temperature monitoring equipment than was evident in first round interview. From this it can be construed there was a severe reluctance on the part of this participant to adopt the technology. For example:

*"I can't see any benefits of data logger/RFID. I think it isn't necessary for live seafood industries" (Case C: S24-25).*

### ***Effects Matrix: Direct, Meta and Side Effects: Organisation C***

This *Effects Matrix: Direct, Meta and Side Effects* can be found in Appendix 2.3.2.

In this matrix there are three major perspectives: *Application objectives*, *As seen by administrator* and *As seen by partner*. Within these the analysis are each further divided into *Systems*, *Processes*, *Relationships* and *Performance*. No changes were identified that were related to the relationship with all the *Meta Effects* perspective.

#### ***Systems Perspective***

From the perspective of *Systems*, the participant did not offer any issues that relate to these changes. From this result it appears that the participant had a lack of interest in the technology. As a consequence this negative view had a detrimental impact on the perceived effectiveness to be gained from the use of the technology.

#### ***As Seen by Administrator Perspective***

From the perspective of *As seen by administrator*, little change was expected to occur as evidenced by negative *Direct Effects* (3), neutral *Direct Effects* (4), positive *Direct Effects* (2) and positive *Side Effects* (2). There were no changes in negative and neutral *Side Effects*. These results suggest that the use of the technology is more likely to achieve *Direct Effects* rather than *Meta* and *Side Effects*. However, it is interesting to note that there have been some attempts to adopt the technology as shown in *Side Effects*. For example the participant stated:

*"I will use data loggers/RFID technology if they can reduce insurance costs as I don't insure my products. The premium for transportation is very expensive and it's not necessary to insure" (Case C: S10-12).*

*"I will use the data logger/RFID only in summer times as we have had problems in summer times. I will use just only once a month" (Case C: S13-15).*

This results show that Participant C was prepared to implement time-temperature monitoring equipment for specific purposes.

Changes in *Processes* in *Direct Effect* were equal in negative and neutral (4 each). However, in changes in *Side Effects* there were more negative (5) than neutral (3) and positive (1). The experience of the participant in doing business was cited as having a negative impact on an acceptance of time-temperature monitoring equipment. As the participant continued to qualify that experience by stating that the technology was not an important business tool to improve quality assurance of products. The participant stated that it depended heavily on external factors such as nature of products and season periods. As the participant stated:

*“Just help us to understanding the fish go through that type of temperature and that we know for example you know that’s bad so what can we do on that” (Case C: 78-80).*

*“We don’t know, yet but at the end you might like a nature product and then all your effort all your work if waste your time” (Case C: 167-168).*

*“From every state in summer time no matter who the processors are they still experience quality problems. We have problems too” (Case C: 182-183).*

For *Relationships* a majority of entries were in the neutral *Side Effects* (3) and the least equal number of entries was in the neutral *Direct Effects* and negative *Side Effects* (1 each). Due to uncertainly about of the technology and nature of the product, the participant thought that the relationship with supply chain partners was less important. In addition, it appeared that there was a complete lack of interest in quality assurance and control and that there was a general atmosphere of disinterest towards time-temperature monitoring equipment. As the participant stated:

*“Exporters try to get products survival as much as they can, they don’t care whether products are fresh or not, just as long as they are alive” (Case C: S19-20).*

No changes were identified that were related to *Performance*. It is interesting to note that the participant did not associate a great level of importance with involvement in the technology. In addition, the participant indicated that the only impact that was noted as the most important issue was improving the survival rate.

#### *As Seen by Partner Perspective*

No changes were identified that were related to *As seen by partner perspective*. This can be explained in that the use of the technology was internal within this organisation and precluded the need for relationships with supply chain partners.

#### ***Explanatory Effects Matrix: Organisation C***

This *Explanatory Effects Matrix* can be found in Appendix 2.3.3.

No changes were identified that were related to *Short-term Operational* and *Long-term Strategic*. The use of the technology was introduced with a low level of interest from the participant. The lack of support and resources from the participant has also had negative implications for the development of the technology. The most important impact that was noted as a result of the changes was an ability to improve survival rate of products. This result was thought to be contributing to the *Mid-term Tactical Change* because the participant is able to use time-temperature monitoring equipment to help to improve the quality of products. The participant stated:

*“It’s just to help us find out during transportation what the main issues of the products are when they are arriving, such as survival rates. Whether we are using what Kantipa is doing or other type of loggers it helps us to understand what is going on inside the box. The main result is to improve the results for the products and the surviving rate. We still need to know whether there is a temperature problem that can lead to customer complaints” (Case C: 7-13).*

#### *System Perspective*

From the perspective of *System* the only information identified was located in *Mid-term Tactical* (5). This could mean that if the participant implemented data loggers, he would be able to improve the survival rate of products. The participant also felt



that the technology is good and particularly effective when it provided a good understanding of his supply chain management.

*“The main issue we take a tag can be tough, can be improved the quality but better the tag can help us to improve the quality, even the tag tell us hey the temperature above is higher or the temperature in the box is no different one or two degrees when you pick them out what the reason we still don’t know” (Case C: 68-71).*

*“We might let’s say once or twice in winter and once or twice in summer we only find out the temperature and once we know the temperature we probably try to find out if the temperature is too high. We could try to chill down a bit more packing or we put one more ice pack and try to improve without so that the best help for us and whether we can improve the quality of product or not it’s another story” (Case C: 226-231).*

#### *Process Perspective*

From the perspective of *Process: transportation of products* the participant did not identify any changes that were related to a relationship with *Short-term Operational, Mid-term Tactical* and *Long-term Strategic*. Due to low involvement with the technology the participant was not sure about the capability of it to improve survival rate and quality assurance all along distribution chain. The participant was not involved with the technology and did not feel that it would bring benefits to him. As he commented:

*“Just help us to understanding the fish go through that type of temperature and that we know for example you know that’s bad so what can we do on that” (Case C: 78-80).*

#### **Summary of the Three Matrices for Organisation C**

The participant in Organisation C identified the following issues:

- The main goal was the improvement of the quality of the product, especially the survival rate;

- Any change in quality assurance of food was likely driven by nature of products and seasons;
- He was not interest in time-temperature monitoring equipment and saw the technology as an unnecessary;
- If he wanted to use the technology, he would use it for specific purposes; and
- Monitoring of the whole supply chain was not seen as important, only from the point of unloading, through processing and delivery.

A most significant finding was the negative attitude towards the technology. These views were supported by the responses to all three matrices that proved to be negative overall. This result indicated that although time-temperature monitoring equipment had many potential benefits, the participant was not interested in using the technology. It also appeared that there had been very minimal organisational impact as a result of using the technology with the only noticeable improvement being the reduced cost of insurance premiums. However, it should be noted that Organisation C had not implemented time-temperature monitoring equipment at the time of the interviews. It could therefore be expected that this case would not yet have had a reasonable exposure to the technology as compared with the experiences the other cases. In addition, due to the nature of distribution chain of live products, which did not need to consider about food safety as long as products are alive, appeared to be another factor to make the participant less positive about the technology.

#### **5.1.3.2 Key Effects-outcomes from Causal Diagram**

The structure and nature of analysis and interpretation of the cause-effect tables was presented in Section 4.3.3. The interpretations presented in this section are focussed a combination of the outcomes from Interview 1 and 2.

##### ***Interviews 1 and 2***

As the result of an analysis of the three matrices with the Managing Director in Organisation C a network of causal relationships was developed using the transcript data from Interviews 1 and 2. This is graphically depicted in Figure 5-5. For ease of reading larger versions of the causal diagram can be found at Appendix 3.5.

As shown in Figure 5-5 for Interviews 1 and 2 from Organisation C, there are 8 input factors and 1 outcome. Within this there is a pathway that forms a link between these based on intermediate issues (A-F).

***Summary of Causal Diagram: Organisation C***

It can be seen from Figure 5-5 that the experience of adopting time-temperature monitoring equipment has been mixed for Organisation C. The participant indicated that there had been negative and positive sides to the adoption of the technology that had impacted directly or indirectly on the effectiveness of the use of it.

The ability to *Understand the cold chain (Input 1)*, *The cost of the technology (Input 2)* and *Reduce cost of quality assurance (Input 3)* lead to *Implement RFID for time-temperature monitoring (A)*. It was indicated by the participant that the technology allows *Products to be monitored all along the cold chain (B)*. By enhancing the quality and quantity of information on environmental factors during transportation it is anticipated that it will be possible to *Understand the biology and factors relevant to the quality of the final products (C)*.

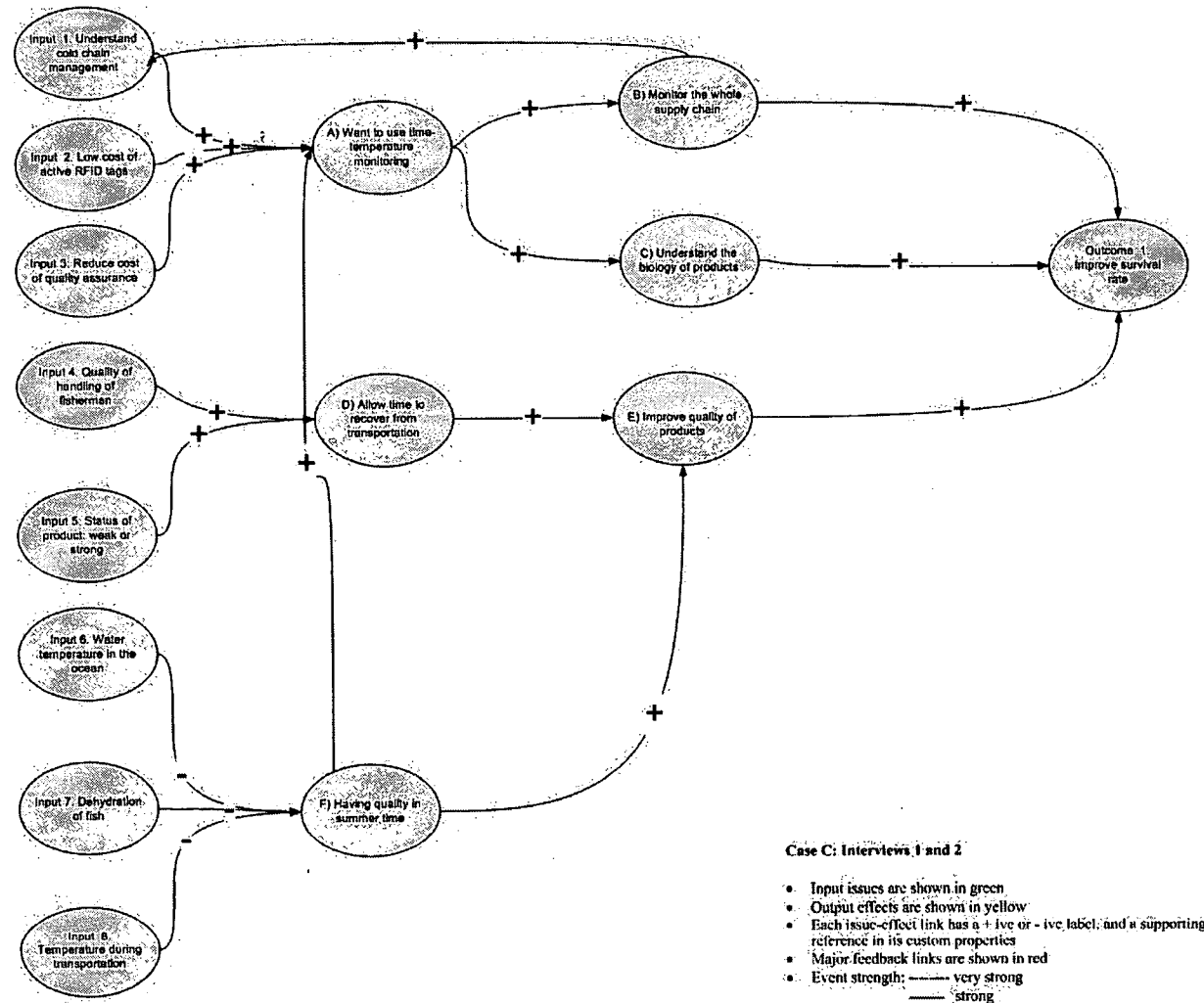
The most common factors that were referred to by the participant as influencing the quality of products were the *Handling of fish by fishermen (Input 4)* as rough handling effects the quality of the products. Other factors such as *Status of products (Input 5)*, *Water temperature in the ocean (Input 6)*, *Dehydration of fish (Input 7)* and *Temperature during transportation (Input 8)* also impact to the quality of the product. Seasonal factors and *Duration of transportation (D)* play a major role, with *Quality issues being most important in summer (F)*, due to the higher temperature and weaker, younger products. Participant C saw that *Active RFID technology (A)* could solve the problems associated with *Quality of products during the summer period (F)*. The main impact of *Monitor the whole supply chain (B)*, *Ability to understand the biology of products (C)*, *Improve quality of products (E)* lead to *Improve survival rate (Outcome 1)*.

Since this was the single outcome in this causal diagram it is supported as the main goal of Organisation C.

Table 5-6 shows the summary of input factors and outcomes of the causal diagram.

**Table 5-6. A Summary of the Input Factors and Outcomes of the Causal Diagram Analysis: Organisation C**

Input Factors	Outcomes/Achievements
<ul style="list-style-type: none"> <li>• The ability to understand the cold chain management</li> </ul>	<ul style="list-style-type: none"> <li>• Improve survival rate</li> </ul>
<ul style="list-style-type: none"> <li>• The relatively low cost of RFID technology, especially compared with conventional data loggers</li> </ul>	
<ul style="list-style-type: none"> <li>• The ability to reduce cost of quality assurance</li> </ul>	
<ul style="list-style-type: none"> <li>• The recognition of the quality of handling of fishermen</li> </ul>	
<ul style="list-style-type: none"> <li>• The status of products</li> </ul>	
<ul style="list-style-type: none"> <li>• Water temperature in the ocean</li> </ul>	
<ul style="list-style-type: none"> <li>• Dehydration of fish</li> </ul>	
<ul style="list-style-type: none"> <li>• Temperature during transportation</li> </ul>	



**Figure 5-5. Causal Diagram: Organisation C (Interviews 1 and 2)**

### **5.1.3.3 Overall Summary Findings: Organisation C**

To recap, as pointed out in the previous chapter because this participant is using English as a second language it caused problems in the transcription and, in turn, the quality of quotations.

Organisation C is one of the biggest exporters of aquaculture products from Tasmania. The business is a unique business with few staff. Due to the relative inexperience of the organisation regarding the technology and the degree of uncertainty regarding the actual benefits that the business would experience, the organisation had taken a more cautious wait and see approach. The business model required the delivery of live products to customers that attract a relatively high price. Taking the view of the nature of the products, seasonal factors play a major role with quality issues being most important in summer. This was due to the higher temperatures and the fact that fish were younger and weaker. The participant stated that the temperatures involved sea and room temperatures as well as the quality of handling of the products by fisherman were seen as the main factors in determining survival of products.

The overall perception within the organisation regarding the adoption of the technology was resoundingly negative. The purpose of the implementation of time-temperature monitoring equipment was to be able to identify the problems that the company faced in meeting the challenges of improving survival rate of products and pinpointing the causes of the problem during the transportation of products from the point of capture to customers. The participant viewed the technology as a support tool to help understand the cold chain and not as a business tool offering potential organisational benefits. The participant was not prepared to commit any further resources pursuing the technology possibilities. Due to the nature of the industry they operated in, the use of time-temperature monitoring equipment was not seen to be a major contribution to their business success as the products were delivered alive. Also due to the size of the business, the distribution process of the products, the participant did not perceive that there would be significant advantages from the technology. Moreover, the lack of technical knowledge and quality assurance processes in Organisation C, monitoring of the whole supply chain may not be

important, except for part of the supply chain from unloading, through processing and delivery. However, whole of supply chain monitoring would help to understand the biology and factors relevant to the quality of the final product.

In addition, the issue of ROI on time-temperature monitoring was not a major issue for the business strategy. The major issues identified were to improve quality of products and survival rate. The organisation saw the need to implement time-temperature monitoring equipment as dependent on the season. It actively looked at how best they could implement time-temperature monitoring equipment to help them to understand temperature during the transportation of products. The analysis of the data demonstrated a general lack of awareness of the need for quality assurance of products apart from problem diagnosis. Organisation C involved with selling live products to overseas, therefore the issue of contamination was not a major issue for them. However, by enhancing the quality and quantity of information on temperature, humidity, duration and location of the products during transportation it was anticipated that it would be possible to reduce mortality rates and improve overall stock control and logistics management.

The major point that was derived from the findings concerning the use of the technology was that the organisation should consider it as a tool to be used especially in the summer period to avoid quality problems. The reduction in wastage of the products brought about by the use of the technology could allow the organisation to retain the position of cost saving market share in a highly competitive industry.

#### **5.1.4 Case D**

Organisation D represents a food safety science research organisation in Australia. The organisation has been involved with two technology service providers (to be identified as 'Organisation PDC' and 'Organisation RFIDS'). 'Organisation PDC' provides Nano-Corn Node technology while 'Organisation RFIDS' provides RFID technology.

#### 5.1.4.1 Effect-outcome Matrices Findings

The structure and nature of analysis and interpretation of the effect-outcome tables was presented in Section 4.3.2. Within this section the findings from the three matrices will be presented.

##### *Change Matrix: Organisation D*

This *Change Matrix* can be found in Appendix 2.4.1.

With respect to Organisation D no changes were identified at the *Preferred Changes*. This suggests that the organisation largely focusses on current issues rather than planning for the future.

##### *Systems Perspective*

From the perspective of *Systems* an equal number of *Immediate* and *Secondary Changes* were revealed (6 each). It was thought that the participant considered the importance of *Immediate* and *Secondary Changes* were equal even though different emphasis was placed on each change. As the participant described, the *Immediate Changes* column refers to the fact that quality assurance and technology, such as data loggers and Nano-Corn Node technology, are linked with the business criteria that cold chain logistics organisations require to meet satisfactory quality and safety standards. The *Secondary Changes* column implies that cost, reliability and accuracy of the technology are factors that have indirect effects. It appears that if there is greater uptake of the technology to encourage more users, then this could decrease the capital costs as well as improve the technology. This in turn, could encourage an increase in usage of the technology and drive costs down even further. This view was supported by the participant who stated:

*“Wireless sensor things seem to be coming in and the price points are coming down” (Case D: 17-18).*

In addition, the results of the matrix indicated that the participant had some negative views towards active RFID technology as supplied by ‘Organisation RFIDS’:



*"They are not long read range anything, they are pretty old, pretty first generation" (Case D: 15-16).*

While he expressed positive attitudes towards Nano-Corn Node tags as supplied by 'Organisation PDC':

*"The outcomes are very positive, the communication is reliable, excellent and the accuracy of the sensors was fine" (Case D: 143-145).*

*"In 'Organisation PDC's system they are chunked away. They are one use, you buy them, and they are guaranteed to be able to detect about half a degree or something, so you wouldn't be out of cost. But um, from our point of view, our reference thermometer cost 'Organisation PDC', cost about a grand about every year or so they get recalibrated" (Case D: 565-569).*

Within the Diffusion of Innovation theory (Rogers, 1995), he sees this technology more useful. It implies that he would be more likely to adopt and implement it. It is interesting to note that the results from the comments of this participant were broadly consistent in his views as a food safety expert. That is, he tends to respond from a food safety standards perspective rather than active RFID technology. There were few direct comments on the use of active RFID technology as the participant heavily focussed more on Nano-Corn Node technology from 'Organisation PDC', than active RFID technology (from 'Organisation RFIDS'). It implies that he did not see this technology fit in his business, so he rejected active RFID technology.

#### *Processes Perspective*

From the perspective of *Processes* issues related to *Immediate Changes* far outweighed (7) those identified as *Preferred Changes* (1). No *Secondary Changes* emerged at this perspective of analysis. This result appears to have been driven because after having experience with active RFID and Nano-Corn Node technology the participant was easily able to identify *Immediate Changes*. Because of this focus he did not extend his views to *Secondary Changes*. It might be that because of his focus on *Immediate Changes* he saw little need to identify any *Preferred Changes*.

*Relationships to Supply Chain Partners Perspective*

With respect to the *Relationships to supply chain partners perspective* the participant identified changes only in the *Immediate Changes* column (7). This implies that the organisation largely depends on their private development company ('Organisation PDC') to build their business framework. Having this partnership was also considered to be important in ensuring that the validation of the technologies was effective. The development of a well-balanced team with a strong technical background was seen as an essential business tool. This result suggests that the participant considered the partnership to be a necessary part of doing their business. In contrast, 'Organisation PDC' also largely depends on the participant's facilities to develop their technology. As the participant stated:

*"They make use of our facilities over the last couple of years, just come and use our cold rooms and been involved and hooking their gateways up to our refrigerated containers and things" (Case D: 11-13).*

*"Once those field trials have been completed, and they have hopefully demonstrated that the product works, then there will be the commercialisation phase. So they try and find capital to fund the mass production and try and find customers for the product" (Case D: 459-462).*

***Effects Matrix: Direct, Meta and Side Effects: Organisation D***

This *Effects Matrix: Direct, Meta and Side Effects* can be found in Appendix 2.4.2.

No changes were identified that were related to relationship with all *Meta* and *Side Effects*. It was thought that the participant considered his job and the involvement with the private technology service provider tend to be more *Direct Effect* rather than *Meta* and *Side Effects*.

In this matrix there are three major perspectives: *Application objectives*, *As seen by administrator* and *As seen by partner*. Within these the analysis is further divided into *Systems*, *Processes*, *Relationships* and *Performance*.

*Application Objectives Perspective*

From the perspective of *Application objectives* the participant did not identify any changes. It implies that the participant was more focussed on the involvement of 'Organisation PDC'.

*As Seen by Administrator Perspective*

For *System* the majority of entries were in positive *Direct Effects* (3), and the least number of entries was in negative *Direct Effects* (1). This result shows that the positive *Direct Effects* changes were perceived as highly important, while the negative and neutral *Side Effects* had only moderate importance attached to them. In addition, the participant had a positive attitude towards to the system as he stated:

*"I think the price will come down" (Case D: 98).*

For *Processes*, the participant identified changes only in neutral *Direct Effects* (9). This outcome could be due to involvement in pilot tests with the two technology service providers ('Organisation PDC' and 'Organisation RFIDS'). These provided an insight and understanding of the two technologies and because the position of the participant as a food safety expert he experienced no effects in terms of process.

For *Relationship*, the majority of entries were in neutral *Direct Effects* (5), and the least number of entries were in the neutral negative (1) and positive *Direct Effects* (1). This evidence suggests that 'Organisation PDC' had a dual role in the relationship perspective within Organisation D. Not only did 'Organisation PDC' have a direct relationship with the perceived level of success associated with the adoption of their technology, it was also an important facilitator for managing and developing the technology. Both of which were perceived to have a positive influence in building a successful relationship. As the participant stated:

*"He has had a production run of the 400 odd tags or whatever he needs to a few trials made, so that's the generation one product that will go to market" (Case D: 53-55).*

*"What 'Organisation PDC' is really wanting from us is the stamp to say that it works. But at the same time his field trials are a bit of a marking place for*

*him because he's running them with people that will be hopefully be customers for him. And so he kind of wants them to realise how important having a temperature monitor is, so to point out to them that there is a possible weakness here" (Case D: 555-556).*

In addition, from the results of the comments from this participant it clearly showed his responsibilities and relationship with 'Organisation PDC' and supply chain partners:

*"We are dealing with the equipment suppliers rather than the users and it's I guess return on investment is fairly important for them but that, one of the strong key drivers I guess is around getting it to the point where you know they almost sell on the fact that they will reduce their insurance cost and to cover the cost of the tags" (Case D: 151-155).*

*"We tend to deal more with the trucking rather than with the quality logistics kind of people" (Case D: 252-253).*

*"The idea of the field trials is that we are going to do an intensive survey of the temperature of the truck. 'Organisation PDC' will put in as many as he suggests that they will use, which is probably one per palette. And we just cross reference that we have got the full dataset. This is what science Australia, measured as the temperature variability of this truck. This is how good your truck is" (Case D: 464-468).*

#### *As Seen by Partner Perspective*

No changes were identified that were related to *As seen by partner perspective* as the participant signed the confidentially agreement with 'Organisation RFIDS':

*"I'm not sure that I can say actually, we signed a contact with 'Organisation RFIDS'. So, probably it's not to" (Case D: 121-122).*

#### ***Explanatory Effects Matrix: Organisation D***

This *Explanatory Effects Matrix* can be found in Appendix 2.4.3.

For *Explanatory Effects Matrix* from the *System* perspective two issues were identified. The first was related to the use of *Nano-Corn Node* technology and the second was related to *RFID technology system*. The temperature monitoring (between the two technologies) was identified in *Processes*.

#### *System Perspective*

For the *Nano-Corn Node technology perspective* a number of changes were identified. The majority of the issues were related to *Description of Changes* (5). *Long-term Strategic* had the highest number of changes (2) and the least change found in relation to *Mid-term Tactical* (1). It implies that the participant had a positive attitude towards *Nano-Corn Node technology*. It would appear that the participant has a strong positive relationship with 'Organisation PDC' that developed the *Nano-Corn Node technology*. As the participant stated:

*"Organisation PDC they also do light, they have a little light sensor in there as well so you can see when the doors are opened" (Case D: 62-63).*

*"Like the thermo coupler I was using it's plus or minus 0.2 or 0.3 and it seems that it's a bit of ... like there is no reason for it to be put to be so big, because, you know, the wireless communication doesn't mean that it should have less accuracy" (Case D: 130-133).*

For *RFID technology perspective* only two *Description of Changes* and single information on *Mid-term Tactical* and *Long-term Strategic* were identified. From the result it appeared that the participant had a negative attitude towards the functionality of active RFID technology.

*"Organisation RFIDS' one's just temperature, temperature and the unique ID code approved for each of the tags" (Case D: 61-62).*

However, the participant clearly stated that active RFID technology seemed to be a tool to improve distribution chains and reduce wastage. This result could mean that the adoption of the technology has the potential to protect brand consciousness through the monitoring of quality control standards throughout the organisation's supply and distribution chains. As the participant commented:

*"You could collect information from the RFID's, that will help you choose the best company and maybe reduce your wastage and it will pay for itself in that type of way. With a lot of products it is a safety thing there is a brand thing. So, there is a brand protection as well" (Case D: 358-361).*

### **Process Perspective**

For *Temperature monitoring (between two technologies) perspective* the majority of the issues were related to *Description of Changes* (12), and the least number of entries were in *Long-term Strategic* (2). It was clearly stated that the pilot tests with 'Organisation PDC' and 'Organisation RFIDS' had a valuable role to play in facilitating the development of monitoring distribution chains. Validating the two technologies had dual 2 purposes. The first purpose was concerned with the validation of two technologies. The second purpose aimed to determine how to apply the best use of wireless technologies:

*"They [model of temperature distribution in containers and trucks] have been a few recommendations in the literature as to how many data loggers that you can use, but there hasn't been any for a long time and the ones, the recommendations that were made 15 years ago" (Case D: 174-176).*

*"It's one per container, or two in case one fails you know and that the thing that if you're using one data logger per consignment it's going to tell you whether the truck or the container fell over but it's not going to tell you about how well the truck or container was doing its job" (Case D: 181-184).*

*"If you are putting in one or two loggers into your system it is telling you if it is working or not, but it is not telling you how well it is working. And if you really want to know how well it is working you have to use quite a few, but whether if quite a few is 20 or quite a few is 200 or 1000 it depends what your.... As a scientific exercise to characterise a 40 foot container or a truck I am thinking 500 or 600. But if I am a shipper and I want to know if that truck is working pretty good, I am thinking 12 to 20 tops, absolute tops. And if I was to suggest to the apple industry if they were to come and ask me how many data loggers should we be putting into each container, I would be*

*saying half a dozen if you could afford it. Because that's, there are costs involved" (Case D: 531-540).*

### **Summary of the Three Matrices for Organisation D**

The participant in Organisation D identified the following issues:

- The purpose of the trials was the validation of Nano-Corn Node and active RFID technologies;
- Was aware of active RFID for time-temperature monitoring but he focussed more on Nano-Corn Node technology;
- He had a negative attitude towards active RFID technology;
- Considered that the current modelling on temperature distribution in containers and trucks was too old and may not be currently relevant; and
- ROI was an important factor, but reduction on insurance costs should be sufficient to cover the cost of tags.

For Organisation D minimal use of active RFID technology was identified by the participant as having only one positive impact on distribution chains. It was stated by him that he had more positive attitude towards Nano-Corn Node technology than active RFID technology. These positive views were supported by the strong good relationship with 'Organisation PDC'. In addition, the participant reported generally about food safety and how to make the best use of wireless technology.

#### **5.1.4.2 Key Effects-outcomes from Causal Diagrams**

The structure and nature of analysis and interpretation of the cause-effect tables was presented in Section 4.3.3. The interpretations presented in this section are focussed on the outcomes from the Interview 1, Interview 2 and a combination of the two interviews.

##### **Interview 1**

As the result of an analysis of the three matrices with the Food Safety Expert in Organisation D a network of causal relationships was developed using the transcripts data from Interview 1. This is graphically depicted in Figure 5-6. For ease of reading larger versions of the causal diagram can be found at Appendix 3.6.

As shown in Figure 5-6 for Interview 1 from Organisation D, there are 6 input factors and 1 outcome. Within this there is a pathway that forms a link between these based on intermediate issues (A-E).

***Summary of Causal Diagram: Organisation D (Interview 1)***

It can be seen from Figure 5-6 that the changes in the causal diagram came from the trials with 'Organisation PDC' and 'Organisation RFIDS'. Many of changes were perceived to have effected the ultimate level of the adoption of active RFID technology either directly or indirectly through the variables.

*Cost of the technology (Input 1)* and *Cost of the sensors that can put into a RFID tag (Input 2)* were perceived by the participant to be negative links to the *Adoption of RFID for time-temperature monitoring (A)*. The high *Value of products (Input 3)*, *Reduce insurance costs (Input 5)* and *Reduce cost of data management (Input 6)* were considered to be important factors driving the implementation of active RFID technology. It was noted by the participant in interview D-1 that even though the *Modelling temperature distribution in containers and trucks (Input 4)* did not impact directly on achieve ROI on time-temperature monitoring, it could be indicative of the amount of money that supply chain partners had been spending on active RFID technology. The *Adoption of the RFID for time-temperature monitoring (A)* was perceived by the participant to have positive benefits for supply chain partners. The introduction of the active RFID technology enabled *Reduce risk sampling (B)*, *Improve quality assurance (C)*, *Understand the stats and the costs for food safety problems (D)*, *Understand of the problems and supply chains with temperature abuse (E)* and *Reduce public health risks (Outcome 1)*.

While the supply chain participants recognise the critical importance of adopting Hazard Analysis of Critical Control Points (HACCP) compliant handling, processing and reporting procedures within the harvesting, storage and processing phases. They do not have the same attention to quality when planning and monitoring the distribution phases, including transport, handover to distribution centres and flow-through to retail sale.



The major feedback issues that were identified within Organisation D resulted from changes is the ability to *Reduce public health risks (Outcome 1)*. For example, part of the organisation is working to compare and find out the best technology that suit supply chain participants.

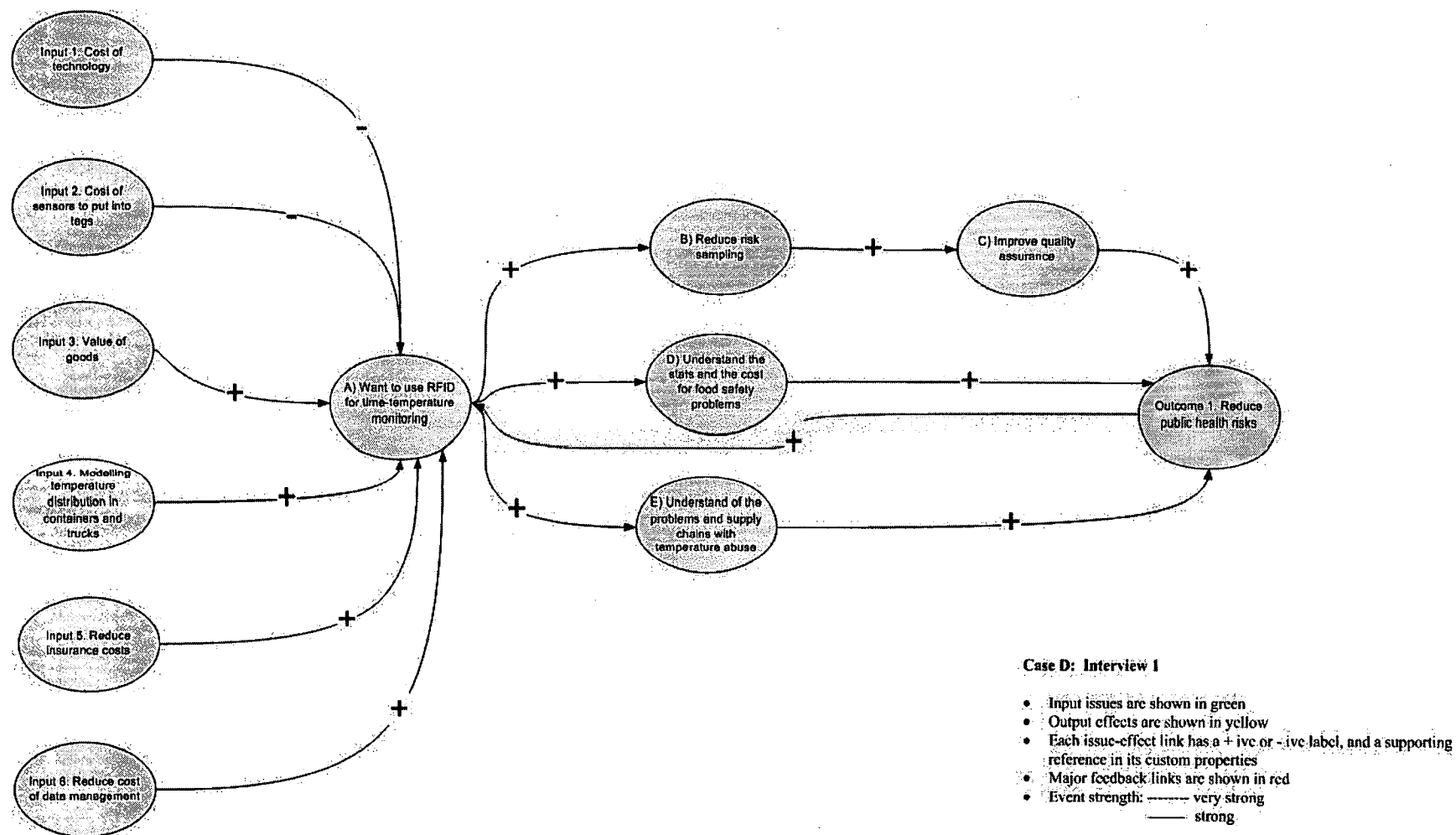


Figure 5-6. Causal Diagram: Organisation D (Interview 1)

**Interview 2**

As the result of an analysis of the three matrices with the Food Safety Expert in Organisation D a network of causal relationships was developed using the transcript data from Interview 2. This is graphically depicted in Figure 5-7. For ease of reading larger versions of the causal diagram can be found at Appendix 3.7.

As shown in Figure 5-7 for Interview 2 from Organisation D, there are 7 input factors and 4 outcomes. Within this there is a pathway that forms a link between these based on intermediate issues (A-F).

**Summary of Causal Diagram: Organisation D (Interview 2)**

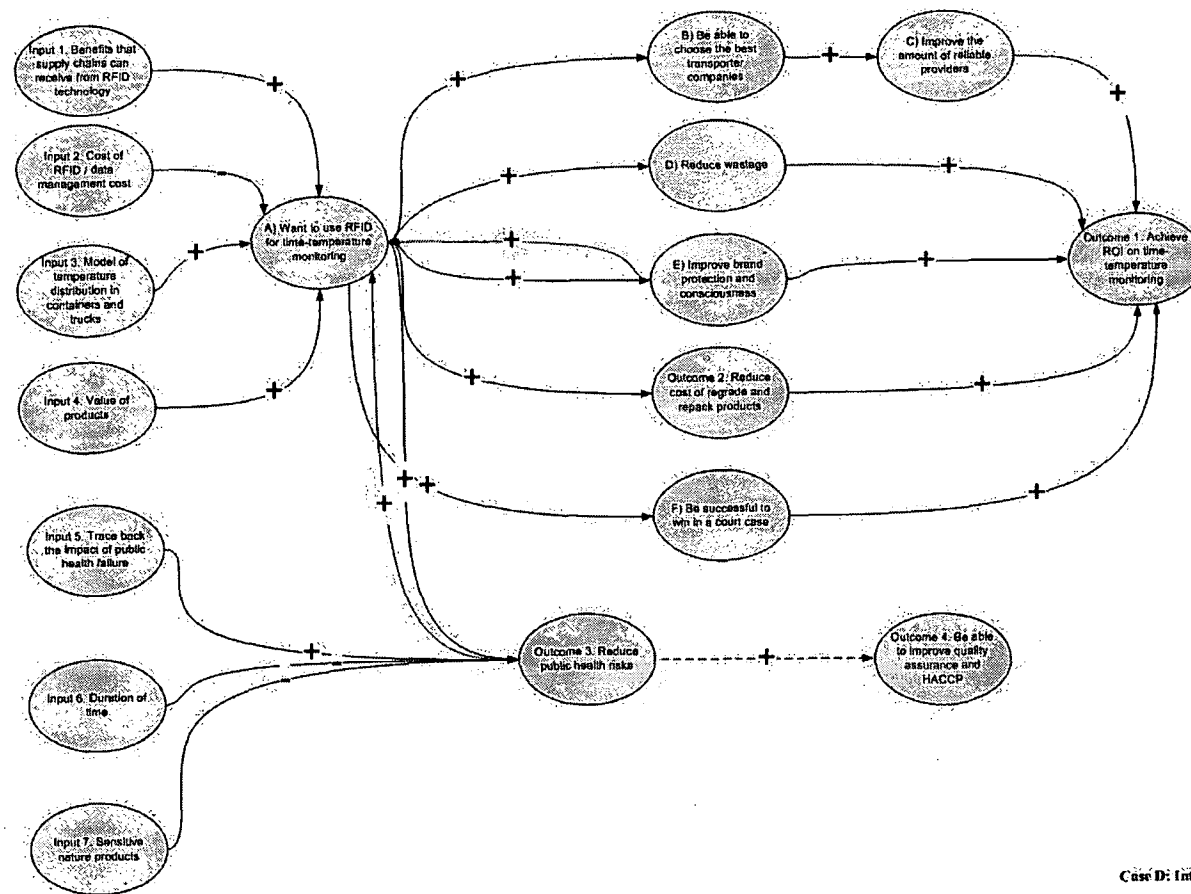
From an overall perspective of the causal diagram for Organisation D Interview 2 the participant mentioned some key issues. This interview mainly focussed on the economic outcome issues during the trials. The participant in interview D-2 agreed that the benefits supply chain participants can expect from active RFID technology are cost of the technology, value of goods and a temperature model. These are the main factors to drive the adoption of the technology.

*Benefits that supply chain can receive from the use of active RFID technology (Input 1), A distribution model of time-temperature in trucks and containers (Input 3) and Value of products (Input 4) were considered to have a positive impact on the Adoption of active RFID technology (A). The Costs of the technology and data management (Input 2) was also considered particularly important although negative to Adoption of active RFID technology low (A). It was stated that Adoption of active RFID technology (A) has been involved at the distribution chain within Organisation D, helping to develop and Review the need for the suitable logistics service providers (B). The number of benefits that the participant mentioned involved Reduce wastage (D), Improve brand protection and consciousness (E), Reduce cost of regrade and repack products (Outcome 2), Be successful to win in a court case (F) and Reduce public health risks (Outcome 3). The adoption of the technology would support and facilitate these changes in supply chains because the collection of data will allow supply chain participants to receive real time information and assess their own effectiveness in the distribution of products. The information from the active RFID technology will also allow the organisation to be able to improve*

the amount of *Reliable logistics service providers (C)*. All four benefits that were mentioned earlier in this paragraph are well received through the adoption of the active RFID technology. Generally they were considered to be having positive effects on *Achieving ROI on time-temperature monitoring (Outcome 1)*.

The ability to track back *Public health failure (Input 5)* was also considered important to *Reduce public health risks (Outcome 3)* and strongly support changes in *Ability to improve quality assurance and HACCP (Outcome 4)*. However, the factors that were referred to by the participant as influencing the effectiveness of the ability to *Reduce public health risks (Outcome 3)* was negatively linked to *Impact of duration of time (Input 6)* and *Type of products (Input 7)*.

Finally, it is interesting to note that there are two major feedback links to *Adoption of active RFID technology (A)*. The ability to *Improve brand protection and consciousness (E)* and *Reduce public health risks (Outcome 3)* had been achieved through the *Use of active RFID technology for time-temperature monitoring (A)*.



## Case D: Interview 2

- Input issues are shown in green
- Output effects are shown in yellow
- Each issue-effect link has a +ive or -ive label, and a supporting reference in its custom properties
- Major feedback links are shown in red
- Event strength: ----- very strong  
 ————— strong

Figure 5-7. Causal Diagram: Organisation D (Interview 2)

### ***A Combination of Interviews 1 and 2***

In the introduction to this section it was established that a third causal diagram was constructed based on a combination of the data from Interviews 1 and 2. The method of doing this was established in Section 5.1. The aim of so doing was to reduce overlap in the models by producing a summary causal diagram to facilitate the formulation of explanation. For ease of reading larger versions of the causal diagram can be found at Appendix 3.8.

The experience of Organisation D with the use of active RFID technology motivated a comparison as a result of the implementation of two technologies (Nano-Corn Node and RFID technology). It can be seen from Figure 5-8 that the experience of adopting the technology for time-temperature monitoring in this organisation has been mixed. It was clearly stated that *Cost of active RFID technology (Input 1)* had a valuable role to play in facilitating the development of *Active RFID for time-temperature monitoring (A)*. *Value of products (Input 2)*, *Modeling temperature distribution in containers & trucks (Input 3)* and *Benefits that supply chains can gain from RFID technology (Input 4)* were also considered to have positive effects on the *Use of active RFID for time-temperature monitoring (A)*. The introduction of the technology has meant that the organisation has been able to *Reduce insurance cost (B)*, obtain *Greater reliability of logistics service providers (C)* and *Improve brand protection and consciousness (D)*. The adoption of the technology has also *Decreased in public health risks (Outcome 2)*. These three intermediate issues (B, C and D) have resulted in an increase in an ability to *Achieve ROI (Outcome 1)*.

The ability to trace back the impact of *Public health failure (Input 5)* was perceived to be having a positive impact to *Reduce public health risks (Outcome 2)*. However, *Duration of transportation (Input 6)* was viewed as a negative impact to *Reduce public health (Outcome 2)*. *Reduce public health risks (Outcome 2)* in turn had helped in *Improving the quality assurance of products (Outcome 3)*.

Table 5-7 shows the summary of input factors and outcomes of the causal diagram.

**Table 5-7. A Summary of the Input Factors and Outcomes of the Causal Diagram Analysis: Organisation D**

Input Factors	Outcomes/Achievements
• Cost of RFID technology	• Achieve ROI
• Value of products	• Reduce public health risks
• Modelling temperature distribution in containers and trucks	• Be able to improve quality assurance of products
• Supply chain participants can gain benefits from RFID technology	
• Public health failure	
• Duration of transportation	

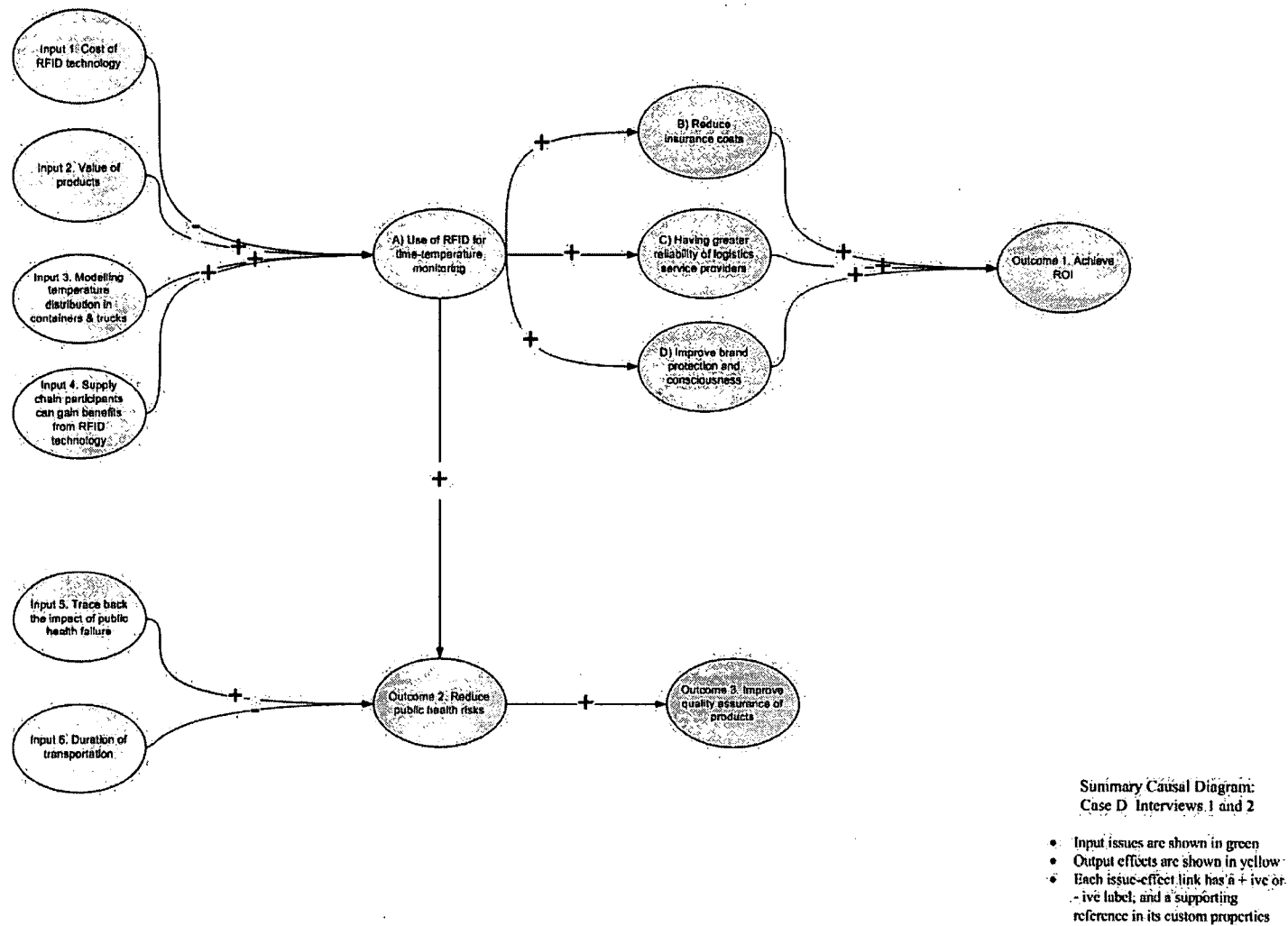


Figure 5-8. A Combination of Causal Diagram: Organisation D (Interviews 1 and 2)



#### **5.1.4.3 Overall Summary Findings: Organisation D**

Organisation D represents a non-profit research organisation located in Sydney. The main purpose of the business is to conduct research on perishable food within Australia and overseas. The participant clearly stated that the knowledge of wireless technologies come from 'Organisation PDC'.

The organisation was involved with two wireless technology service providers ('Organisation PDC' and 'Organisation RFIDS') in undertaking pilot studies. These involve examining RFID technology, data loggers, Nano-Corn Node tag (mobile technology) and thermo couplers. Six laboratory based pilot studies had been implemented across food and pharmaceuticals industries using rail, sea and road transport modes. The main purpose of these trials was the validation of two technologies. Temperature and identify code were the main key factors evaluated during the trials. Other sensing methods, such as light and gas sensing were considered, however the costs were prohibitively expensive. The organisations' pilot studies of the supply chain focused on simulated trucking across the packaged stage, either from source to processor or from processor to distribution centre. The participants reported that the result of the Nano-Corn Node tag was positive, the communication was reliable and the accuracy of sensors was good. However, the pilot studies revealed a number of problems associated with the use of active RFID technology; in particular related to the read range of first generation RFIDs.

Participant D who had previous experience with similar pilot studies and saw the technology as a means of more effectively expanding business. The use of active RFID technology was principally used to improve the level of quality assurance of products and to streamline business processes to reduce public health risk. The analysis of the interview with Organisation D revealed that ROI was not an important issue, as it deal mostly with technology service providers and the issue of ROI was more important for them. However, the reduction in insurance costs, focus on brand consciousness and the protection of brand image were considered sufficient to cover the cost of RFID tags. In order to accommodate ROI from active RFID technology, the participant reported that two cost factors need to be considered: data management and insurance costs.

Active RFID technology for time-temperature monitoring could be used as a sophisticated alternative to protect public health, reduce wastage as well as reduced cost of regrade and repacks. The driver for the use of the technology in this company was an ability to understand the problems in supply chains with temperature abuse, consequent food safety problems, costs and the current unknown outcomes of food safety. From examining the interview it was also evident that while HACCP was required, the handling of goods during transportation was almost missed in HACCP. Participant D indicated that most logistics managers and logistics service providers lack an awareness of the importance of the adoption quality assurance measures along the distribution chains of perishable foods.

The company recognised the critical importance of adopting HACCP compliant handling, processing and reporting procedures within the harvesting, storage and processing phases. However, it did not place same level of importance on quality when planning and monitoring the distribution phases, including transport, handover to distribution centres and flow-through to retail sales. The participant also identified that there was a lack of up-to-date literature that specifically addresses the modelling temperature distribution in containers and trucks. While a model was available to supply chain participants, there remained a significant problem in that it was outdated and so had little current relevance.

### **5.1.5 Case E**

Organisation E is a multinational company that manufactures a variety of confectionary products, including ice-cream and other dairy products. The organisation is located in a business area in Sydney. Organisation E prides itself on its customer service and quality assurance orientation. While the organisation had conducted some active RFID trials with 'Organisation RFIDS' it is not currently using any this technology. According to the Diffusion of Innovation theory Roger (1995), this organisation can be regarded as "early majority", that only wants to buy a productivity improvement for the existing operation.

### 5.1.5.1 Effect-outcome Matrices Findings

The structure and nature of analysis and interpretation of the effect-outcome tables was presented in Section 4.3.2. Within this section the findings from the three matrices will be presented.

#### ***Change Matrix: Organisation E***

This *Change Matrix* can be found in Appendix 2.5.1.

#### ***System Perspective***

For Organisation E *System perspective* revealed that the majority of entries were in *Preferred Changes* (14) whereas the number of changes for *Primary Changes and Secondary Changes* were similar, with 9 each. This suggests that from the data analysis, the overall effect of changes in the system tended to be strategic rather than immediate and intermediate outcomes. This implies that the ability to improve the distribution chain that was noted by the participant resulted from the use of time-temperature monitoring. It was stated that there had been a considerable increase in the ability to control their supply chain partners and pinpoint root cause of problems as the participant responded:

*“We also had a few quality issues with our distributors here in Australia, for example, we had an issue that ice cream was left at the dock with a temperature of 5°, approximately 5° for several hours. If we had a cheap data logger, or some sort of control, we could prove that the ice cream was subjected to heat shock at that time, at that place. We had to go through a court case to argue our point that when it left the factory it was in good shape” (Case E: 48-52).*

In addition, many of these good practices were perceived to have influenced to the strong commitment to time-temperature monitoring equipment:

*“If we spent \$25,000 over five years, buying these and the administrative costs, it would pay itself off several times” (Case E: 328-329).*

*Processes Perspective*

For *Processes perspective* an equal number of *Immediate* and *Preferred Changes* were revealed (10 each); however, in the category of *Secondary Changes* only 1 was found. This implies that the use of time-temperature monitoring equipment significantly enhances the traditional supply chain processes between the organisation and their supply chain partners. The ability for the organisation to pinpoint root cause of problems and receive real time information has resulted in an improvement in the distribution chains and third parties processes. The participant considered the use of the technology increased transparency, credibility and he perceived that it offered a greater understanding of their cold chain when dealing with their supply chain partners:

*“Would improve our third-party process. This would give us better control of what was happening during distribution of our finished product for example. Because once the product leaves our third party warehouse, then we do not have any control over it. So, and if we use transmitters in the future, if we could use transmitters, then this would give us perhaps better, even better control, because we would know the location of the trucks the timing and in case of accidents, in case of quality issues with the product, linked back with consumer complaints. We would be able to pinpoint the root cause of the problem or the issue” (Case E: 251-257).*

*Relationships to Supply Chain Partners Perspective*

*Relationships to supply chain partners perspective* related to *Immediate Changes* far outweighed (18) those identified as *Secondary Changes* (6) and *Preferred Changes* (6). This implies that the adoption of time-temperature monitoring equipment has resulted in a number of direct benefits dealing with their supply chain partners. For example, the ability to manage supply chain partners remotely using the technology ensures that the organisation maintains control over its supply chain partners providing essential support for quality assurance and food safety without having to be on site as the participant stated:

*“We do audit them, but you cannot be there all the time” (Case E: 144-5).*

Time-temperature monitoring equipment is used as a strategic business tool that facilitates the supply chain partners operation and prohibits the chance to disregard the quality assurance perspective. For example the participant commented:

*"We do have requirements and they need to abide by these requirements"*  
(Case E: 161).

*"They have their own equipment, and they are required to calibrate that equipment. But if we have extra measuring devices on their premises, they certainly shouldn't object to it. And we would be more than happy to do that"* (Case E: 164-166).

The organisation relies heavily on supply chain partners to manage their distribution chains. The ability for the organisation to control their supply chain networks provides an avenue to reduce wastage, maintain the quality of products and improve trackability and traceability as the participant stated:

*"We have got five different transport companies dealing with this, because we have been dealing with X works. So the product leaves Singapore, and one transport company picks it up and delivers the container to the port. Then another transport company puts it on the ship. When it comes to Sydney, another transport company picks it up and delivers the product to our third party warehouse. It sits there and then from there it is delivered to the company. We open it and it is fused, and we have got six people potentially and they blame each other. So then we put a data logger in there"* (Case E: S69-76).

#### ***Effects Matrix: Direct, Meta and Side Effects: Organisation E***

This *Effects Matrix: Direct, Meta and Side Effects* can be found in Appendix 2.5.2.

For Organisation E in this matrix there are three major perspectives: *Application objectives*, *As seen by administrator* and *As seen by partner*. Within these the analysis are further divided into *Systems*, *Processes*, *Relationships* and *Performance*.

*Application Objectives Perspective*

From the perspective of *Application objectives* no issues related to *Relationship*, *Performance* and *Meta Effects* were identified. For *Systems*, there was no evidence of neutral *Side Effects* changes. However, the majority of entries were in the positive *Direct Effects* (7) and only a few in negative *Direct Effects* (3), neutral *Direct Effects* (1), negative *Side Effects* (3) and positive *Side Effects* (2). These outcomes could imply that the cost of acquisition of time-temperature monitoring equipment was not considered to be a significant factor when determining whether to invest in the technology. It was thought that the cost of damaged products, replacement cost and cost of dealing with supply chain partners emerged as the most important issues during distribution of products and it appeared that the technology was accepted as a tool to reduce these problems. The comments made by the participant clearly indicated that he had a positive attitude towards the technology. This enthusiasm for the adoption of the technology has also resulted in an increase in the level of customer services and a greater pressure on supply chain partners to follow the organisation's quality assurance and food safety policies. As the participant viewed that:

*"So the cost, this cost, the cost of quality, the cost of writing off the product, dumping the product, finance department being involved in the logistics and quality assurance. So all together it certainly justifies spending an extra few bucks buying these data loggers even if it is just a one year data logger"* (Case E: 63-66).

*"It certainly would be bringing some cost benefits. Cause the cost of the quality ones and there is a big issue escalates enormously, exponentially really. More departments are involved, I could only estimate. But, say, for example, if we had to write off one the container of finished products, then on top of the cost of the product. It could probably be another \$10,000 in costs of time, and all that together"* (Case E: 285-288).

*"We would prevent issues. We would be able to pinpoint where the issue occurred and that would dramatically reduce the cost of quality"* (Case E: 331-332).

At the *Processes* perspective a majority of entries were in the positive *Direct Effects* (6) and the least number of entries were in the neutral *Direct Effects* (3), negative *Side Effects* (2), and positive *Side Effects* (2). These changes in turn have both had a positive and negative influence on the overall quality assurance and distribution of products effectiveness. For example, the positive influence of time-temperature monitoring equipment:

*"We would have perhaps better more accurate results" (Case E: 399).*

Its use was further supported:

*"Products got damaged because of heat abuse, and there was a dispute"*  
*(Case E: S160-161).*

#### *As Seen by Administrator for Systems Perspective*

From the position of *As seen by administrator for systems perspective* the majority of equal entries are in the positive *Direct Effects* and positive *Side Effects* (3 each) and the least number of entries are in the neutral *Direct Effects* (2). The participant did not identify any changes that were related to all *Meta Effects*, negative *Direct Effects*, negative and neutral *Side Effects* as well as *Performance* column. It implies that the attitude of the participant provided a strong positive message, that time-temperature monitoring equipment has shown potential benefits to the organisation. This positive message was thought to be helping develop further positive changes in organisational distribution chains. For *Processes* the issues related to positive *Side Effects* far outweighed (10) those identified as negative *Side Effects* (2) and neutral *Side Effects* (5). Not all *Direct* and *Meta Effects* emerged from this perspective of changes. It implies that the participant was more consistent in his views towards changes in the quality of distribution of products and relationship with their supply chain partners. Overall, it appeared that there had been considered improvement in the distribution networks since the introduction of time-temperature monitoring equipment. It was noted that there appeared to be a greater transparency supply chain networks where the organisation can pinpoint the root cause of problems. The ability to justify using the technology has meant that the overall processes would be more effectiveness as the participant stated:

*“We will save money in terms of quality; cost of quality will be reduced. Preventing of recurring big issues. Also, yeah, preventative action is the most powerful one” (Case E: 320- 321).*

*“We would prevent issues. We would be able to pinpoint where the issue occurred and that would dramatically reduce the cost of quality” (Case E: 331-332).*

For *Relationship* the issues related to neutral *Direct Effects* far outweighed (15) those identified as negative *Direct Effects* (4), positive *Direct Effects* (5), negative *Side Effects* (4) and positive *Side Effects* (1). No *Meta Effects*, neutral *Side Effects*, and all *As seen by partners* were identified. From this outcome it was considered that this organisation is quality assurance and control oriented. The attraction of time-temperature monitoring equipment appeared to be a major driver for the organisation to establish the transparency, validity and reliability of products all along distribution chains:

*“We do have a third party quality control process so we do inspect every container, we do inspect every batch” (Case E: 220-221).*

*“Because we do an audit of every supplier, we only buy products from suppliers approved from XXX” (Case E: 229-230).*

In this quotation XXX has been used to protect the anonymity of a body in the perishable food industry.

*“We review each supplier at least once a year. We audit them on a frequent basis, and yeah, we require certain things from them. They need to sign specifications, they need issue certificates of certification of analysis and performance” (Case E: 232-234).*

*“Good guidelines and good processes for them to follow. You know, how to put the stock in freezers, how to maintain the freezers, how to handle it” (Case E: S141-143).*



For Organisation E at the *Performance* the majority of entries are in the negative *Direct Effects* (5) and the least number of entries are in the positive *Direct Effects* (1). This can be interpreted that the use of the technology ensured cost saving internal and external to the business. A common cost saving for the organisation was a reduction in cost associated with a heat shock incidents. Internal cost savings relate to those associated with distribution and handling, quality control and warehousing. External cost savings were seen as third party quality control and legal expenses:

*“We will save money in terms of quality, cost of quality will be reduced”  
(Case E: 320).*

*“We are starting to quantify early this year and cut some of the costs. It is a combination of administration costs, QA costs and logistics department involvement” (Case E: S100-101).*

#### *As Seen by Partner Perspective*

No changes were identified that were related to the relationship with all *As seen by partner perspective*. It implies that the adoption of time-temperature monitoring equipment was internal within this organisation and precluded the need for relationships with supply chain partners. However the participant indicated that this situation will change in the future when it is planned to established partnerships with supply chain members.

#### ***Explanatory Effects Matrix: Organisation E***

This *Explanatory Effects Matrix* can be found in Appendix 2.5.3.

#### *System Perspective*

For *Explanatory Effects Matrix* from the *System perspective* two issues were identified. The first was related to the use of *Data logger system* and the second was related to ‘*Organisation RFIDS*’ system. The process of monitoring through the distribution/temperature reading was identified in *Processes*.

For the *Data loggers perspective* a number of changes were identified. The majority of the issues were related to *Description of Changes* (7). *Long term Strategic* had

the highest number of changes (4), the *Short-term Operational* (3) was lower while the least number of changes were found in relation to *Mid-term Tactical* (1). Looking at the pattern of responses from this participant it can be seen that he had a more positive view about data loggers. This suggests that in this organisation data loggers are seen as performing well. It was also thought by Participant E that he has made use of these on their production and distribution processes and this had generally satisfied the participant. These results were expected as the previous matrices (*Change Matrix* and *Effects Matrix: Direct, Meta and Side Effects*) have shown that the experience of the participant with their usage is considerably more positive as they have shown many potential benefits. For example the participant viewed:

*“If we had a cheap data logger, or some sort of control, we could prove that the ice cream was subjected to heat shock at that time, at that place” (Case E: 50-52).*

*“So the cost, this cost, the cost of quality, the cost of writing off the product, dumping the product, finance department being involved in the logistics and quality assurance. So all together it certainly justifies spending an extra few bucks buying these data loggers even if it is just a one year data logger” (Case E: 63-66).*

For ‘*Organisation RFID’s*’ system perspective the majority of the issues were related to *Description of Changes* (10). An equal number of *Mid-term Tactical* and *Long-term Strategic* (4 each) as well as *Short-term Operational* (3) were revealed. This evidence identified that the adoption of time-temperature monitoring equipment had helped improve not only immediate strategy but also intermediate and long term strategy. In addition, the participant was more consistent in his view towards the adoption of the technology:

*“It seemed to be a very good system to me” (Case E: 75-76).*

Although there was some acknowledgement of the limitation and cost of the technology it was generally thought that it was not considered being a significant factor when compared with quality assurance issues:

*"If we had one, cost us \$25, say \$18, and a couple of dollars maintenance and administration costs, and then this would be much cheaper. With one simple graph, maybe we could say okay, on the 25<sup>th</sup> of August that temperature went out for three hours. And at that time, the container was on particular ship from New Zealand to Australia, and that is when it happened. So, you guys are responsible and this would be clear-cut for us"* (Case E: 333-338).

It appeared that the main problem was the lack of interest in quality assurance of products throughout the distribution chains. This inadequate action then served to compound the cost of warehousing, logistics and administration costs and so made the cost of quality to be an important issue for this organisation.

#### *Process Perspective*

For *Process of monitoring through the distribution/temperature reading* the majority of the issues were related to *Description of Changes* (16). *Long term Strategic* had the highest number of changes (4), while the least equal number of changes was found in relation to *Short-term Operational* and *Mid-term Tactical* (1 each). It can be seen from the table (Appendix 2.5.3) that the *Process of monitoring through the distribution/temperature reading perspective* has had practically very little impact at three perspective of changes (*Short-term Operational*, *Mid-term Tactical* and *Long-term Strategic*). This does not mean that the participant was not concerned with any strategies in the future. For him, it was more a question of where the technology can fit into the organisation. On-going quality issues with supply chain participants meant that the priority for the participant was to implement time-temperature monitoring equipment so these problems could be prevented.

#### *Summary of the Three Matrices for Organisation E*

The participant in Organisation E identified the following issues:

- Was aware of the use of time-temperature monitoring equipment of perishable in transport, and had been involved in some RFID trials with 'Organisation RFIDS';

- Having on-going issues with suppliers;
- Appreciated the potential benefits that time-temperature monitoring equipment could offered to the organisation, both in terms of quality assurance during transport and at third parties' premises, and also to manage the risk of loss or spoilage of food, the risk to public health of incorrect handling and storage;
- Would like third party suppliers to activate time-temperature monitoring equipment when the products leave their premises;
- The organisation conducts risk assessment on its suppliers and review the risk based on triggers; and
- He saw brand image as critical to the success of its continuing marketing and sales.

Organisation E has been very successful in adopting best practice with time-temperature monitoring equipment. It was also identified the adoption of the technology had a large impact on the organisation and that this impact had a positive influence on the overall effectiveness of the cold chain management. Furthermore, the positive attitude of the participant was also considered to be contributing to the effectiveness of the adoption of the technology. These positive comments were strongly supported by the responses in the three matrices that provided evidence that Organisation E had been successful in the adoption of the technology.

#### **5.1.5.2 Key Effects-outcomes from Causal Diagrams**

The structure and nature of analysis and interpretation of the cause-effect tables was presented in Section 4.3.3. The interpretations presented in this section are focussed on the outcomes from Interview 1, Interview 2 and a combination of the two interviews.

##### ***Interview 1***

As the result of an analysis of the three matrices with the Product Quality and Third Party Co-ordinator in Organisation E a network of causal relationships was developed using the transcript data from Interview 1. This is graphically depicted in

Figure 5-9. For ease of reading larger versions of the causal diagram can be found at Appendix 3.9.

As shown in Figure 5-9 for Interview 1 from Organisation E, there are 9 input factors and 3 outcomes. Within this there is a pathway that forms a link between these based on intermediate issues (A-U).

***Summary of Causal Diagram: Organisation E (Interview 1)***

It can be seen from Figure 5-9 that Organisation E has been reasonably successful in adopting time-temperature monitoring equipment but it not has addressed all of the key best practice variables and the level of adoption has varied throughout the project. It seeks to learn how best to use the technology to facilitate increased revenue generation by improving customer services and preventing heat shock problems. Further analysis of these outcomes can categorise them according the time-frame in which they are expected to be achieved:

- Immediate: elimination of secondary costs associated with storage, processing and investigating heat shock incidents;
- Intermediate: the driving of change through the distribution chain through making third party logistics service providers and warehouse managers more aware of the need for compliance with the quality control standards required by Organisation E for transport, handling and storage of their products; and
- Strategic: brand name protection through monitoring of quality control standards throughout their supply and distribution chains.

*Having ongoing quality issues with suppliers (Input 1)* was seen as largely practical supporting *Use of time-temperature monitoring (A)*. A further impact that was identified resulting from the adoption of time-temperature monitoring was that these were a need to *Take the responsibility for goods (Input 2)* from the point of harvest to the factory. The transportation of products can be complex, involving suppliers, insurance companies and logistics service providers. Therefore, the storage, delivery of products requires a reliance on quality of logistics service providers. A strong relationship between these groups is essential to minimise the substantial expenditure that can be involved. The participant also noted that the company deals

with different supply chain partners and *Accident can occur anytime (Input 3)* during transportation. These results were considered by the participant to be influencing the *Adoption of active RFID technology (A)*.

It was noted by the participant in interview E-1 that the organisation *Conducts risk assessment on its suppliers (B)* on a six monthly review basis assist to *Gain assurance that supplies have not been heat shocked (D)*. These are incorporated into the procurement management strategies of the company against the established standards on *Acquisitions of supplies set by the company (N)*. A focus on quality control and assurance of products through the distribution chains by the participant translated into a perceived need to employ time-temperature monitoring technology that would provide a high degree of surveillance of the conditions of handling and storage of the products. Such technology would then greatly assist in *Conducting inspection and testing of suppliers (B)* and the resolution of faults that lead to *Heat shock incidents (D)*. The time-temperature data obtained through the use of such technology would *Uncover actual and near heat shock incidents (C)* where handling and storage standards were not adhered to, including incidents where the heat exposure was *Not sufficient to damage the stock (E)*. The time-temperature data could then be employed to build evidence to take *Legal action against third party logistics service providers (Outcome I)* to at least recover the costs associated with loss of products and the associated reverse logistics expenses incurred. Such action was expected to lead to a rapid increase in the standards of quality control of handling and storage of the products.

There was a more important factor noted by the participant with respect to *Heat shock problem during the transportation of products (Input 4)*. During the summer periods several consignments of products are typically *Subjected to heat shock (F)*. In addition, *Inspect products that have been heat shocked (G)* can mean the consignments are withdrawn from markets and held in cold storage warehouses, typically for up to several months while the nature and cause of the problem are investigated. Often due to a lack of evidence *Spoilt products were subsequently dumped (H)*. Overall it is thought that such problems have incurred *Cost of quality assurance (I)*, *Cost of loss of the product (J)* and *Cost of management and negotiation with insurance companies (K)*. The costs associated with a heat shock

incident were thought to have a number of implications influencing the *Adoption of data loggers/active RFID technology (L)*.

With regard to *Adoption of data loggers (M)*, it was considered by the participant in interview E-1 that this had a positive impact on *Achievement of ROI on the acquisition, use and maintenance of time-temperature monitoring equipment (Outcome 2)*. The *Cost of RFID tags (Input 5)* was also perceived to be having a positive impact on *Adoption of active RFID for time-temperature monitoring (M)*. However, *Cost associated with ongoing license fees (Input 6)* and *Relative high cost of data loggers (Input 7)* led to a low priority being associated with the *Adoption of the technology (M)* and *(T)*. Nevertheless, it was argued that the *User friendly (Input 8)* and *No charge for using software (Input 9)* had positive impacts on *Use of active RFID technology (T)*.

As has been indicated by the participant this organisation is a quality centric organisation. Currently he is developing a strategy to *Improve quality control at suppliers' premises (U)*. This will have a positive impact to *Assure the company's quality control system (N)*. It was also stated that the organisation is driving change by making supply chain participants more aware of the need for compliance with quality control standards. The participant in interview E-1 clearly stated that the company would like their *Suppliers to conduct quality control standard regularly (O)* so that the organisation will be able to *Improve the quality of handling in distribution chain (P)*. The ability to *Improve quality of handling in distribution chain (P)* was considered to have a direct positive impact on the *Adoption of wireless technology (Q)* with the *Useful technology of GPS (R)* to be able improve track and traceability. Developing positive *Wireless technology with GPS facility (Q, R)* was considered to have a direct positive impact on the ability to *Link quality assurance with consumer feedback (S)*. The use of *Wireless technology (Q)* was also seen as having a positive impact on *Ability to improve customer service (Outcome 3)*.

Finally, there were two major feedback noted by the participant. First with respect to *Link quality assurance with consumer feedback (S)* and this change had a positive impact on *Ability to identify root causes of problems (C)*. The second major

feedback was *Achievement of ROI (Outcome 2)* that was expected to be gained from *Improved by implementing time-temperature monitoring (A)*.



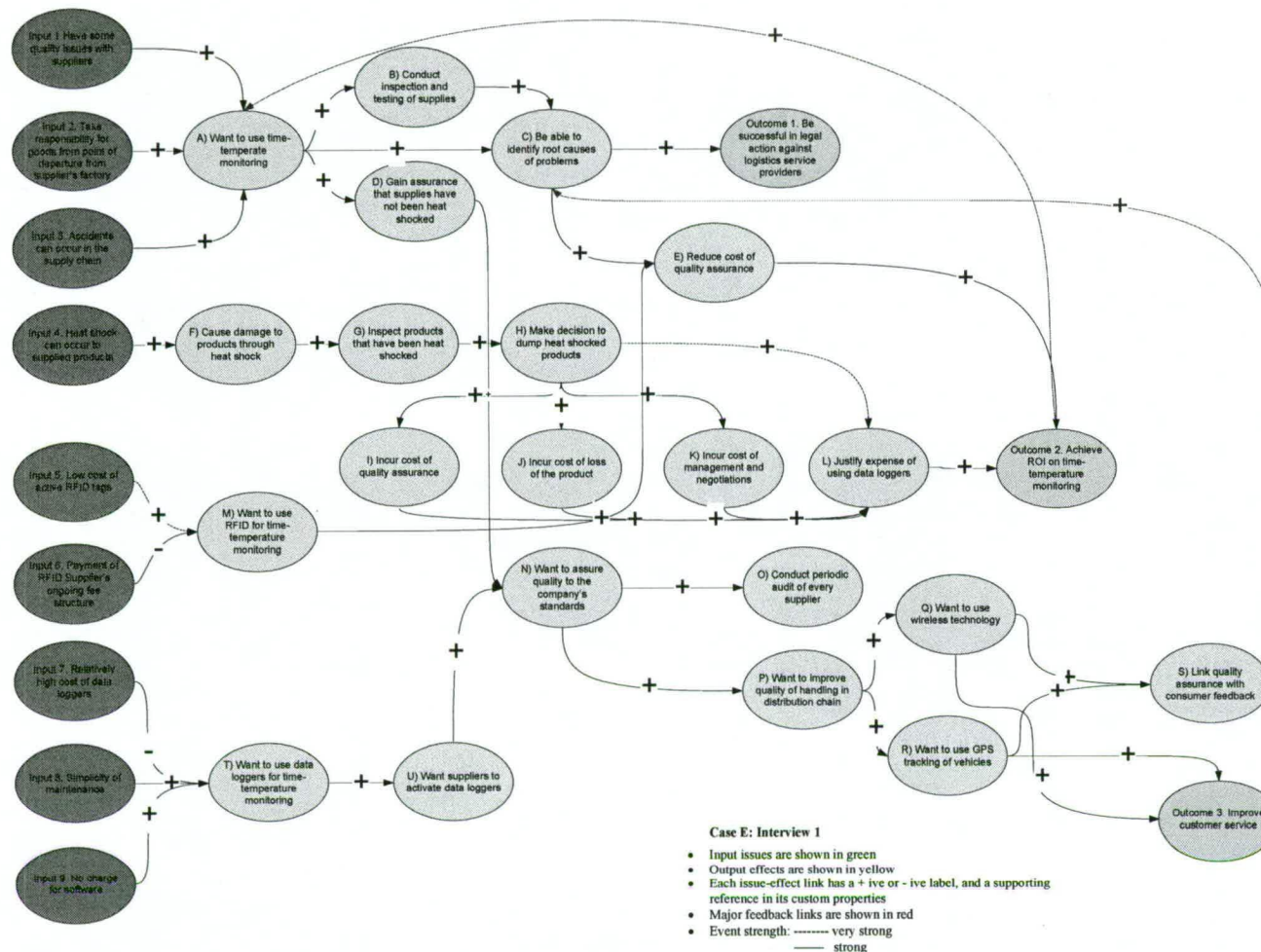


Figure 5-9. Causal Diagram: Organisation E (Interview 1)

**Interview 2**

As the result of an analysis of the three matrices with the Product Quality and Third Party Co-ordinator in Organisation E a network of causal relationships was developed using the transcript data from Interview 2. This is graphically depicted in Figure 5-10. For ease of reading larger versions of the causal diagram can be found at Appendix 3.10.

As shown in Figure 5-10 for Interview 2 from Organisation E, there are 8 input factors and 5 outcomes. Within this there is a pathway that form a link between these based on intermediate issues (A-N).

**Summary of Causal Diagram: Organisation E (Interview 2)**

Figure 5-10 gives an indication of how the level of changes have impacted on the adoption of time-temperature monitoring equipment within in Organisation E. The second round interview focused on the impact of the technology to cold chain management. It can be seen from the diagram that most of the input factors were referred to by the participant were negative.

It was felt by the participant in interview E-2 that the *Complicated invoice system (Input 2)* and *Ongoing license fees (Input 3)* had led to a low priority being associated with the *Adoption of active RFID technology (A)*. However, it was argued that the ability to *Delay programming (Input 1)* and *Ongoing issues with insurance companies (Input 4)* had a positive impact on want to *Use data loggers for time-temperature monitoring (A)*. The participant also indicated that the use of time-temperature monitoring equipment had many potential benefits of *Improving logistics and warehouse management (Outcome 1)*, *Reducing cost of damaged products (B)*, *Reducing cost of dealing with insurance companies (C)* and *The ability to build evidence to take legal action against insurance companies (D)*. From these potential benefits also lead to *Reduce cost of associated insurance (Outcome 2)*. At the same time there was an awareness that *Keeping products in warehouses (Input 5)* occurred *Incurred cost of keeping products (E)* that could result in an accumulating financial outlay for Organisation E. On a more positive note the participant saw potential *Benefits of active RFID technology/data loggers (F)* as it could *Reduce operation cost (G)* and *Reduce cost of quality assurance (Outcome 3)*.

Since the nature of distribution chain of products was based on relatively *Long journeys with many supply chain participants involved in the cold chain (Input 7)* breaks at critical points can cause *Reduce quality assurance of raw materials (Input 6)*. These two problems in turn resulted in *Wanted to use data loggers for time-temperature monitoring (H)* to control cold chain management of their supply chain partners. The participant appeared to have an interest in improving *Quality assurance with GPS facility (K)* across multiple *Third party logistics service providers (I)*. The responses suggested that Organisation E is developing a quality assurance strategy as they want their *Supply chain participant to follow quality assurance standards (J)*. A high level of quality assurance standards across supply chain was thought to be able to *Improve quality of monitoring products in distribution chain (Outcome 4)*. Finally, it was also stated by the participant that *Ongoing issues with heat shock incident (Input 8)* that *Sustain deformation and change in products shapes (L)* had resulted in *High demand of using data loggers (M)*. It was recognised that the use of data loggers in the cold chain could provide *Ability to pinpoint root causes of problems (N)* that could result in *Achievement of ROI on time-temperature monitoring (Outcome 5)*.

Further, the participant in interview E-2 identified that *Ability to reduce cost of associate insurance (Outcome 2)* and *Cost of quality assurance (Outcome 3)* were major feedbacks from *Adoption of the active RFID technology (H)*.

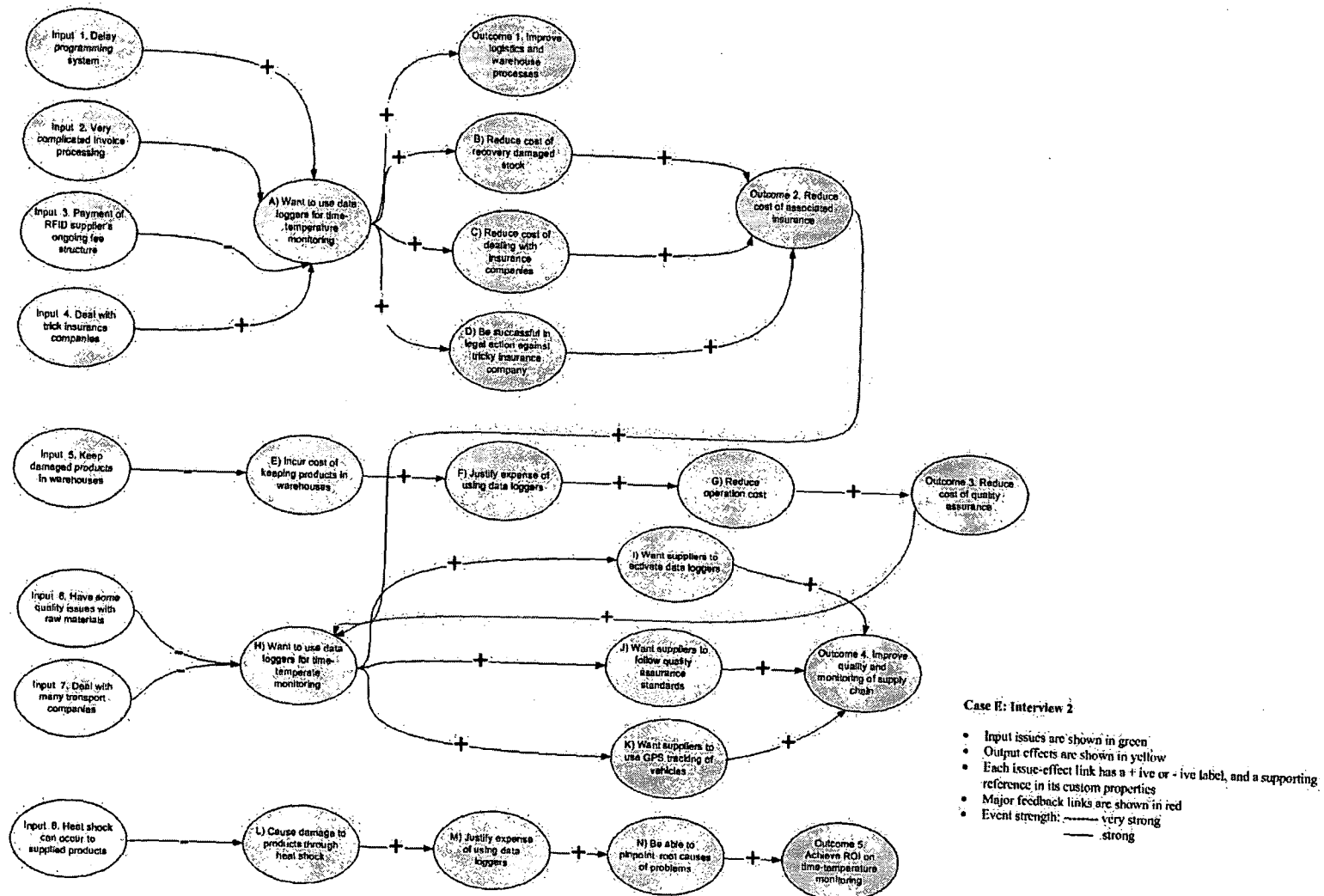


Figure 5-10. Causal Diagram: Organisation E (Interview 2)

### ***A Combination of Interviews 1 and 2***

A third causal diagram was constructed, based on a combination of the data from Interviews 1 and 2. The aim of doing this was to reduce overlap in the models by producing a summary causal diagram to facilitate the formulation of explanation. For ease of reading larger versions of the causal diagram can be found at Appendix 3.11.

It can be seen from Figure 5-11 the participant in Organisation E perceived that the adoption of time-temperature monitoring equipment had been very successful. The technology was perceived to have achieved a desired level of supply chain management effectiveness either directly or through mediating variables. As a consequence of high level of *Quality assurance issues during the transportation of products (Input 1 and 2)*, there was a strong commitment to *Adoption of time-temperature monitoring technology (A)*. Both were perceived to have a direct effect on the ability to *Pinpoint causes of problems (B)*. Furthermore, the *Provision of time-temperature monitoring (A)* has meant that the organisation could achieve *Success in legal court cases (Outcome 1)* thereby *Achieve ROI (Outcome 2)*.

An additional variable that emerged from combining the data from the two interviews was the importance of having *Active RFID for time-temperature monitoring (C)*. It was clear from the comments made by the participant that the adoption of the technology was perceived to *Relative lower cost when compared with data loggers (Input 3)*. However, it would appear that *Ongoing license fee (Input 4)* is more likely to be a negative barrier towards the adoption of the technology. Another variable that emerged was *Heat shock can occur to supplied products (Input 5)*. The heat shock problem was considered to be an important issue to the organisation as it was perceived to be a main factor to determine *Cost of dealing with damaged products (D)*.

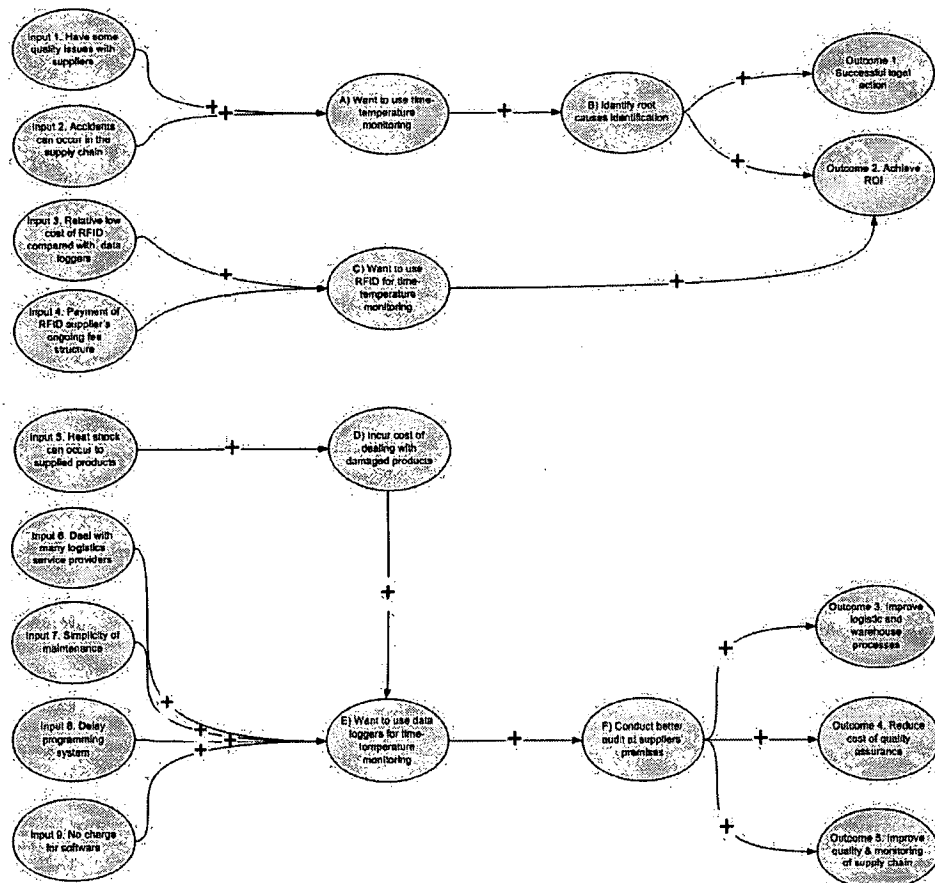
It was also identified by the participant that *Deal with many supply chain partners (Input 6)*, *Simplicity of maintenance (Input 7)*, *Delay programming system (Input 8)* and *No charge for software (Input 9)* were vital in terms of the adoption of *Data loggers for time-temperature monitoring (E)*. Having the data loggers has provided the organisation the ability to *Conduct better audit at suppliers' premises (F)*. It was

stated that because of this the organisation could *Improve logistics and warehouse processes (Outcome 3)*, *Reduce cost of quality assurance (Outcome 4)* and *Improve quality and monitoring of supply chain (Outcome 5)*.

Table 5-8 provides the summary of input factors and outcomes of the causal diagram.

**Table 5-8. A Summary of the Input Factors and Outcomes of the Causal Diagram Analysis: Organisation E**

Input Factors	Outcomes/Achievements
<ul style="list-style-type: none"> <li>The identified existence of a lack of quality with some logistics service providers in the supply chains</li> </ul>	<ul style="list-style-type: none"> <li>The need for greater level of success in the taking of legal action against faulty logistics service providers, and the recovery of losses after heat shock incidents and subsequent dumping of spoilt products</li> </ul>
<ul style="list-style-type: none"> <li>The recognition that accidents can occur in the supply chain, and lead to heat shock incidents</li> </ul>	<ul style="list-style-type: none"> <li>The achievement of ROI on the acquisition, use and maintenance of time-temperature monitoring equipment</li> </ul>
<ul style="list-style-type: none"> <li>The relatively low cost of RFID technology, especially compared with conventional data loggers</li> </ul>	<ul style="list-style-type: none"> <li>The improvement of levels of logistics and warehouse processes</li> </ul>
<ul style="list-style-type: none"> <li>Payment of RFID supplier's ongoing fee structure</li> </ul>	<ul style="list-style-type: none"> <li>The ability to reduce cost of associate insurance and quality assurance</li> </ul>
<ul style="list-style-type: none"> <li>The recognition that companies need to deal with many logistics service providers</li> </ul>	<ul style="list-style-type: none"> <li>Increased ease in the conduct of, and the achievement of more accurate results from, the conduct of periodic audit of the standards of handling and storage of logistics service providers in the supply chains</li> </ul>
<ul style="list-style-type: none"> <li>The need for simplicity of handling and maintenance of time-temperature monitoring technology</li> </ul>	
<ul style="list-style-type: none"> <li>Delay programming system</li> </ul>	
<ul style="list-style-type: none"> <li>No charge for software</li> </ul>	



Summary Causal Diagram:  
Case E Interviews 1 and 2

- Input issues are shown in green
- Output effects are shown in yellow
- Each issue-effect link has a +, - or -/- label, and a supporting reference in its custom properties

Figure 5-11. A Combination of Causal Diagram: Organisation E (Interviews 1 and 2)

### **5.1.5.3 Overall Summary Findings: Organisation E**

Organisation E is an importer and exporter of finished products and raw materials around the world. The company has a very good understanding of food safety, customer orientation and quality assurance all along the cold chain. The company has been involved in some trials with a service provider, but is not currently using any time-temperature monitoring equipment. Organisation E was very dynamic in its product development and rapid product to market cycle. It had in place well defined quality control standards, risk assessment and audit procedures. It saw the need to implement time-temperature monitoring both on their supply and distribution chains as a production requirement, not just an interim measure for validating their third party handling and storage standards. The use of time-temperature monitoring equipment was a strategic initiative to bring the high standards of manufacturing and production that Organisation E already applied to its own operations. This would then facilitate the rapid roll-out of new products by quality assuring the distribution chains of such products, so that its brand image was protected and its product innovation was transparent to the marketplace.

A focus on quality control and assurance of products through the distribution chains by the Product Quality and Third Party Co-ordinator translated into a perceived need to employ time-temperature monitoring technology that would provide a high degree of surveillance of the conditions of handling and storage of the products. Time-temperature monitoring equipment was seen to greatly assist in the resolution of faults that lead to heat shock incidents. The time-temperature data obtained through the use of the technology could uncover actual and near heat shock incidents where handling and storage standards were not adhered to, including incidents where the heat exposure was not sufficient to damage the stock. To at least recover the costs associated with loss of products and the associated reverse logistics expenses incurred. The time-temperature data could then be employed to build evidence to take legal action against third party logistics service providers. This action was expected to lead to a rapid increase in the standards of quality control in the handling and storage of the products.



Despite the complexity of the ownership channels in the distribution chains of Organisation E, sharing of information between owners was seen as desirable in recognising the partnership arrangements established through their distribution contracts and required to achieve their strategic outcomes. This organisation was clearly the leader in the supply chains in which it participated. It was confident of its own quality assurance standards and sought to achieve continuous improvement in the quality assurance practices of all of its supply chain partners.

The company had experience with temperature abuse during the cold chain with consignments needing to be rejected or dumped. Recovering the cost of damaged stock, and dealing with insurance companies in this company was significant. The costs associated with a heat shock incident were compounded by several factors:

- Loss of flow of goods to consumers, and the replacement cost, plus potential loss of continuing business;
- Bureaucratic handling required to reship the effected goods;
- Bureaucratic handling required to account for the loss and prepare insurance and potential legal claims for such loss;
- Warehousing required to retain the affected goods for a period of time, at least until the insurance claim had been handled, and potentially until the legal claims were handled;
- Legal expenses associated with developing a case for compensation and initiation of legal proceedings; and
- Reverse logistics costs associated with disposal of the affected goods after the period of time of retention of the spoilt goods had elapsed.

Therefore, the company was very keen to adopt a monitoring solution in order to improve quality of products and reduce ongoing costs. The company had a third party quality control process and implements a risk analysis system. The company inspected every container and every batch. The frequency of inspection depended on the confidence in the process and the nature of the product. The company would like third party suppliers to activate data loggers when the products leaved their premises, for monitoring at the pallet level. This would identify the pallet and the data could be downloaded on arrival and checked for quality assurance purposes.

The purposes for the use of time-temperature monitoring equipment were to monitor:

- Temperature in containers;
- Temperature of raw materials during delivery; and
- Temperature and truck movements during delivery.

The company had very limited experience with active RFID tag technology. While the technology showed great promise, in being inexpensive and easy to place amongst cartons, it also had several drawbacks:

- RFID tags used in trials were not sufficiently rugged to withstand the very cold, wet and rough handling environment required to monitor the entire supply chain;
- RFID tags did not offer close to real-time feedback on time-temperature readings, but needed to be returned to a reader attached to a personal computer. A reading facility was not readily available in the field;
- Business model associated with the RFID tags required the organisation to enter into a long term licensing arrangement with ongoing license fees and a mode of reading and feedback that could only be performed via the Internet;
- Number of data points and the lifetime of the RFID tags were considered very limited; and
- Limitation of the data logger that company had been faced was physical effects such as metal detectors can affect tag performance.

The company identified the significant outcomes of the use of time-temperature monitoring equipment were quality and consumer safety against micro contamination. Two issues contributed to ROI in time-temperature monitoring equipment. First, the ability to command a higher price based on quality of the product; second, the ability to prevent recurrence of major problems. These were largely attributed to the supply of raw materials, and being able to pinpoint the cause of failures in the cold supply chain.

Financial constraints have previously been cited in the literature as barriers to the adoption of the technology (Twist, 2005). From a review of the interview it became apparent at an early stage in the interview that ROI was not considered to be the most important factor when considering costs and other justifications for the adoption of RFID tag technology. The cost of acquisition of RFID tags was not seen as a dominant issue when determining whether to invest in active RFID for time-temperature monitoring technology. The handling costs, the improvement of customer service and protection of brand image were considered to be the major factors, especially when evaluated against the current level of loss of products due to heat shock incidents in the distribution chain.

The achievement of ROI was so obvious with any of the available monitoring technologies that it was not a major issue for a solution that integrated with the business and logistics models of the company. For Participant E the major issues identified were to find and adopt a technology that fitted and enhanced existing standards and procedures so as not to impose new, disruptive business models. The trial with a particular RFID tag had the outcome of providing experience with a satisfactory monitoring technology. However the business model of licensing and data management imposed by the provider of the RFID tags did not integrate with Organisation E's established business processes. That is their focus is on quality assurance and brand protection.

Key issues identified were:

- A need for a suitable business solution: the technology and modes of operation must fit into the operations, standards enforcement and business models of the company;
- A reduction in the time, effort and resources required for the lengthy processing and storage of spoiled products and the adoption of close to real-time fault detection and identification of the systems and service providers at fault;
- The development of end to end quality assurance of materials and products that protected the brand image of the company; and

- The development of production processes, based on the use of rugged, robust technology that could be employed in harsh, low temperature conditions with relatively little maintenance.

## **5.2 Cross-Case Analysis: a Comparative Evaluation of the Five Case Studies**

This portion of the chapter provides further analysis of the case studies, beyond the within-case display results presented in Section 5.1. It will focus on a cross-case comparison, using the results for each case, based on the key variables that were identified from the earlier analyses. These seven key issues were identified as being common across the five case studies:

- Return on investment (ROI) - the expected period over which capital financial outlay will be recovered;
- Change management - the extent to which the introduction of time-temperature monitoring equipment will create change in the organisation;
- Time-temperature monitoring - the equipment associated with time-temperature monitoring;
- Food regulation and quality assurance issues - issues associated with government regulation of quality assurance during the processing and handling of perishable food;
- Limitations of technology - the constraints of time-temperature monitoring equipment;
- Relationship to supply chain partners - the extent to which members of a supply chain interact; and
- Recovery of information using time-temperature monitoring equipment.

The comparison examines the similarities in these key variables across the five case studies. These comparisons resulted in the extraction of relationships that were found to be replicated across multiple cases, and abstracted from individual cases. As noted by Eisenhardt (1989:541), “the juxtaposition of seemingly similar cases by a researcher looking for differences can break simplistic frames”. During this process, it became clear that the adoption of time-temperature monitoring

equipment had similar effect-outcome relationships in all cases. The five case studies also present a range and variation in intensity of participant concerns related to the adoption of this technology.

### 5.2.1 Comparison between Five Cases: ROI

Table 5-9 shows that of the five cases examined in this research, Organisation E regarded ROI as a very important consideration in the adoption of time-temperature monitoring equipment. It was identified as common in all aspects of the three analyses matrices with only one exception. This related to *Side Effects* in *Effects Matrix: Direct, Meta and Side Effects*. While it was indicated that they had not been able to measure ROI, the participant did suggest they were experiencing returns through more indirect ways, and in that respect they were generating returns on their investment. As the participant commented:

*“But I can give you a figure if, um... if we spent \$25,000 over five years, buying these and the administrative costs, it would pay itself off several times” (Case E: 328-329).*

Organisation B identified ROI as an issue in four of the nine levels of analysis within the matrix. The omissions related to *Preferred Changes* in *Change Matrix*, *Side Effects* in *Effects Matrix: Direct, Meta and Side Effects* and all *Explanatory Effect Matrix*. This could indicate that Organisation B had concern about ROI because they considered that once active RFID technology for time-temperature monitoring was fully implemented, they would be more concerned about the total cost of RFID tags and readers. As the participant stated:

*“If you said, let's say that you are going to do it for three or four different customers at up to about 200 bucks a week that might be a bit high” (Case B: 366-367).*

Organisations A, B and D raised a similar number of issues in relation to ROI. However, Participant D held the view that ROI is more important for users of active RFID technology than him as a non user. For example, the participant stated that:

*"I guess we are dealing with the equipment suppliers rather than the users and it's I guess return on investment is fairly important for them" (Case D: 157-158).*

*"I don't probably have that much insight in terms of cost factors. I am sort of a step back from operations" (Case D: S41-42).*

Even though Organisation A identified the importance of ROI in Chapter 4, no *Secondary Changes in Change Matrix, Meta Effect and Side Effects in Effect Matrix: Direct, Meta and Side Effects, Mid-terms Tactical and Long-term Strategic* issues were identified when a case by case comparison was made. This suggests a low level of senior management commitment, which had resulted in a lack of interest in considering the ROI on this technology. Participant A stated that the adoption of active RFID technology had generally been given a very low priority within the organisation, and most recently this had been manifest in a strong reluctance from senior management to support the use of the technology.

*"Ok it is a critical issue, we're asking to spent money, and I go to MD or whatever and I say I want to spend, even \$5,000 or 10, 50 or 100 first question is, what are we going to get back? What's the payback?" (Case A: 379-382).*

*"I've tried to make the agreement that we should be using RFID a lot more throughout the plant and I just can't make it because I don't have hard information on what the potential benefits are in terms of hard cash outcomes" (Case A: 441-444).*

Participant A was concerned about the ROI as he tried to develop a business case to make an agreement to extend the adoption of active RFID technology in the organisation. As he stated:

*"When I read the information sheet from Kantipa that why yes, I immediately .....if we can build a business case. It will help me and what I'm trying to achieve. So, I think it's very good" (Case A: 24-26).*

*"I would love to see your economic modelling because it will assist me in what I'm trying to achieve, and I spent a lot of my time involved in modelling various parts of the business, process flows, volume flows, and just the economics of running the business. So I'm more than happy to look at modelling that look at the delivery of models and see how they work. So yes I'm very happy to be involved"* (Case A: 458-464).

Participant A believed that by providing more tangible evidence of the financial returns on active RFID technology, decisions to increase the adoption of the technology would occur. In turn, this would facilitate direct benefits to the organisation through greater efficiency of their cold chain management.

*"Well look, at the moment, to make, it's making the commercial case that is going to kill this, and that's, this will either get up will not, at the moment everybody is saying that cold chain control is important... Nobody can put a value on it, and people play around numbers like you know temperature abuse in transit costs the Australian, you know 10 billion or 76 million or whatever a year. If you actually ask us what temperature abuse costs us, in terms of product disposal, gee probably nil. Almost nobody throws stuff away, what it does is undermine the confidence customers in your ability to deliver. It might lead to credit claims and we got information on file about people who have made claims that clearly are the result temperature abuse so we can start to put value against it, but it is then also making the link and saying if I'm spending 15, 20, 50 or whatever it is thousands of dollars setting up a formal RFID system, will we actually stop that happening or are we in fact just imposing a cost which there is no benefit and it's that link that we are missing"* (Case A: 471-486).

In contrast to the four earlier cases, the findings for Organisation C indicated the least concern about ROI. Here, the participant demonstrated a lack of interest in time-temperature monitoring equipment as he did not see it of any importance. As the participant commented:

*"The issue of ROI isn't important for us as we don't need to know" (Case C: S 48-49).*



## Return on Investment

**Table 5-9. Summary the Relationship of Five Cases Between ROI and Three Matrices**

Case	Change Matrix			Effects Matrix: Direct, Meta and Side Effects			Explanatory Effects		
	Immediate Changes	Secondary Changes	Preferred Changes	Direct Effects	Meta Effects	Side Effects	Short-term Operational	Mid-terms Tactical	Long-term Strategic
A	√		√	√			√		
B	√	√		√	√				
C	√					√			
D	√	√		√					√
E	√	√	√	√	√		√	√	√

√ = issue identified

### 5.2.2 Comparison between Five Cases: Change Management

The level of identification of change management as an issue varied across the five cases, as shown in Table 5-10. Organisation E regarded change management as a very important consideration in the adoption of time-temperature monitoring equipment. It was identified as common in all columns of the matrix in Table 5-10, with only one exception. This related to *Meta Effects* in *Effects Matrix: Direct, Meta and Side Effects*.

Organisation B identified change management as an issue in six of the nine levels of analysis within *Effects Matrix: Direct, Meta and Side Effects*. The omissions related to *Side Effects* in *Effects Matrix: Direct, Meta and Side Effects* as well as *Short-term Operational* and *Long-term Strategic* in *Explanatory Effects Matrix*. The participants in Organisations B and E indicated that the use of active RFID technology for time-temperature monitoring had a direct positive impact on their organisations. The main type of change management identified in these organisations focussed on improving cold chain management. These two cases also considered that their adoption of active RFID technology would provide a competitive advantage through having value added services to entice customers to remain loyal to the company. As the participants stated:

*“But I think we could print out and fax it to them, it could be part of our customer service” (Case B: S294-295).*

*“I think it also, it could improve our customer service” (Case E: 267).*

Organisation D identified the same number of change management relationships as in Organisations A and C. For example these were identified for Organisations A, C and D in all aspects of the matrices, with five exceptions. For Organisations A and C these related to *Preferred Changes* in *Change Matrix*, *Meta Effects* and *Side Effects* in *Effects Matrix: Direct, Meta and Side Effects* as well as *Short-term Operational* and *Long-term Strategic* in *Explanatory Effects Matrix*. While for Organisation D the exclusions related to *Preferred Changes* in *Change Matrix*, *Meta Effects* and *Side*

*Effects in Effects Matrix: Direct, Meta and Side Effects as well as Short-term Operational and Mid-terms Tactical in Explanatory Effects Matrix.*

It is interesting to note that while there has been change management occurring within Organisation A, it has not led to considerable changes in the organisation. The participant reported that their internal and external processes have performed well and it would appear that the change management practices had limited impact in this respect. As the participant from Organisation A commented:

*“So we’ve had a couple of successes in terms of cold chain control. But as much as anything it has been about the ease of confirming that what we are doing is in fact correct” (Case A: 341-343).*

Participant C provided contrasting views on the level of change management, indicating that time-temperature monitoring equipment was perceived to be occurring at high level in some areas such as improving survival rate, but not others. For example, he stated:

*“To help me to understanding all the procedure transportation handling, but the most important is to improve survival rate” (Case C: 104-105).*

Participant D considered the cost of the technology to be prohibitive. This negative message was in turn thought to reduce the perceived change management required in the organisation. The participant made the following commented:

*“Yes, it’s just a matter of cost” (Case D: 94).*

## Change Management

**Table 5-10. Summary the Relationship of Five Cases Between Change Management and Three Matrices**

Case	Change Matrix			Effects Matrix: Direct, Meta and Side Effects			Explanatory Effects		
	Immediate Changes	Secondary Changes	Preferred Changes	Direct Effects	Meta Effects	Side Effects	Short-term Operational	Mid-terms Tactical	Long-term Strategic
A	√	√		√				√	
B	√	√	√	√	√			√	
C	√	√		√				√	
D	√	√		√					√
E	√	√	√	√		√	√	√	√

√ = issue identified

### 5.2.3 Comparison between Five Cases: Time-temperature

#### Monitoring

Table 5-11 shows that across the cases, the decision to adopt time-temperature monitoring was a very important consideration, especially in Organisation E. This issue was identified within all aspects of the matrix. These results suggest that the technology had widespread impacts in Organisation E. The very positive message across Organisation E related to the improvement of tracking and traceability, reduction in the costs associated with reverse logistics of dealing with heat-shocked products, and reduction in on-going issues with supply chain partners. Further, it was considered that this technology would increase the distribution chain effectiveness and the returns from the value chain. Participant E made the following comments:

*“We also would like to use some kind of data log or temperature monitoring for some of our own materials because we have had some quality issues with our suppliers. In particular our chocolate supplier. We have had some issues with suppliers from which we buy X-works. That means that they throw the container and then it is our responsibility from then on as soon as it leaves their factory. And that includes several transport companies, shipping companies, and anything can happen during the journey and a temperature monitoring would give us a clue” (Case E: 23-29).*

*“We import some blocked ice products, which are more susceptible to heat shock. Very sensitive to temperature changes, and we had a couple of instances where whole containers had to be rejected and dumped, at the cost in excess of \$20,000. Now, this definitely justifies spending extra money and using the data loggers. A), we may be able to reduce our inspection and testing program of imported stuff. B) we were definitely able to monitor and have assurance that that product has not been heat shock during the journey, and if it has been heat shock, it might of happened, for example, happen and during in Europe or China during the loading. So that will enable us to pinpoint the root cause of the problem” (Case E: 41-48).*

Organisation B identified time-temperature monitoring as an issue in six of the nine perspectives covered in Table 5-11. The omissions related to *Side Effects* in *Effects Matrix: Direct, Meta and Side Effects* as well as *Short-term Operational* and *Long-term Strategic* in *Explanatory Effects Matrix*. The most common factor that was referred to by the participant as driving the adoption of time-temperature monitoring practices was impending demand from the large supermarkets. As the participant said:

*“We have an interesting relationship with Coles and Woolworths that we sit round this table with them as a supplier,...in Sydney we will be the direct supplier, because we are going to supply into their distribution centre” (Case B: 332-339).*

In addition, the experiences reported at Organisation B illustrated how time-temperature monitoring was important to them:

*“It comes to Hobart cold storage centre, loaded onto Westgate trucks, delivered via the Spirit of Tasmania into Melbourne, Westgate then put it through their chilled goods dispatch area in Melbourne for delivery to our customers. If it’s going further, they then take it through to Sydney or to Brisbane or to Cairns, wherever we are transporting those products. So it’s a very long supply chain, one that has a lot of risk; a lot of dangers, and we do have problems where carriers fail to handle the product properly” (Case B: 206-213).*

In contrast, low concerns about time-temperature monitoring were identified in Organisations A, C and D where the participants noted that a lack of interest in active RFID technology was associated with a low appreciation of the relevance of time-temperature monitoring. For example, the response from Organisation A supports the assertion that there is a negative relationship between appreciating the need for time-temperature monitoring and the level of perceived success associated with it.

*“Where we actually send them out of the factory through the cold chain, not very successful, about 50% return rate. Part of the issue is that looking at*

*these data loggers people don't recognise them as a data logger, They're not sure what to do with them and so now, \$15 an hour warehouse guy looks at it, doesn't know what it is they get thrown out. People that aren't receivers and transporters are not prepared to handle the data loggers. They see it as an imposition, and they also see it as properly giving us an undue insight into their business and they are not particularly happy with in fact being asked to spy on themselves it's pretty much how they see it" (Case A: 101-110).*

Participant C also viewed time-temperature monitoring as unnecessary:

*"I don't think that I need to use RFID for time-temperature monitoring as our products are alive" (Case D: S 40-42).*

In Organisation D the participant reported that the lack of support for the adoption of active RFID had no effect, as the pilot tests were focused on the validation and comparison of two technologies, rather than for time-temperature monitoring alone. For example, the participant commented:

*"Mostly validation of the technology. That seems to be our goal in that field; proving that the sensors are accurate and reliable" (Case D: 24-25).*

## Time-temperature Monitoring

**Table 5-11. Summary the Relationship of Five Cases Between Time-temperature Monitoring and Three Matrices**

Case	Change Matrix			Effects Matrix: Direct, Meta and Side Effects			Explanatory Effects		
	Immediate Changes	Secondary Changes	Preferred Changes	Direct Effects	Meta Effects	Side Effects	Short-term Operational	Mid-terms Tactical	Long-term Strategic
A	√	√		√					
B	√	√	√	√	√			√	
C	√							√	
D	√							√	
E	√	√	√	√		√	√		√

√ = issue identified



### 5.2.4 Comparison between Five Cases: Food Regulation and Quality Assurance Issues

Table 5-12 shows that for Organisation B, quality assurance issues were a very important consideration in the adoption of active RFID technology for time-temperature monitoring, in comparison with the other four cases. For example, this issue was identified by Participant B in all aspects of the matrix with only three exceptions. These exceptions are *Preferred Changes in Change Matrix*, *Side Effects in Effects Matrix: Direct, Meta and Side Effects* and *Short-term Operational in Explanatory Effects*. It was stated by Participant B that the increase in the adoption of time-temperature monitoring technology was due to of the introduction of new food regulations and that the adoption of greater quality assurance measures. As a result of these changes, the participant and supply chain partners were demanding specific changes to their transportation system to make it more effective and to ensure quality. As the participant stated:

*“The new food safety laws that are coming into place for seafood anyway they are using Tasmania as the guinea pig and I think it’s the 31<sup>st</sup> December or 1<sup>st</sup> of January everybody has to fall in line with those, all those people delivering the products to the Hobart Cold Storage centre on the back of their utes are going to have to stop. I think that’s gonna have December or January is going to be all these people scrambling to find freight companies that can deliver, you know, off the East Coast and the far north East Coast there are not too many options” (Case B: 508-516).*

*“There are two or three growers that we deal with that have small chillers. Half the time, they don’t use them. The time will come with the changes to food standards is going to mean that they are going to have to have chilled trucks” (Case B: S249-252).*

The participant went on to clarify more about quality assurance issues:

*“Especially when you have sensitive, products like seafood and our products are a classic. Yeah, our products are particularly ..... because they have*

*such a short shelf life of about seven days, we would like to push that out to nine days” (Case B: S310-312).*

Organisation E identified this as an issue in five of the nine perspectives of analysis within the matrices. The exceptions were *Meta Effects* in *Effects Matrix: Direct, Meta and Side Effects* and all *Explanatory Effects Matrix*. The participant identified a direct positive relationship between food regulation and quality assurance issues, and the adoption of time-temperature monitoring technology. The participant also stated that the technology had been adopted as a specific objective for the quality assurance of the product. As stated:

*“If it sits there in the dock for two or three hours, while being loaded, then all you need to do. If you can imagine, a box of 5, 5 kilo blocks of products. It is kind of that sort of shape you know and they are in the box like this. All they need to do is partially melt together just fuse a bit, and then be open the box here and our operators can't lift the whole block of products and put it in the melt tank. Because it would damage the agitator, and also it is a safety risk. Because you are talking about 25 kg, it is very awkward. So that is one of the issues that cheap data loggers will probably be used for” (Case E: S80-88).*

In contrast, Organisation C is an example of the organisation that provides live aquaculture products to national and international customers. Therefore the issue of quality assurance of products is not their most importance issue, as the participant stated:

*“Exporters try to get products survival as much as they can, they don't care whether products are fresh or not just as long as they are alive” (Case C: S19-20).*

In Organisation D less concern was shown about food regulation and quality assurance issues than in Organisations B, E and C as this participant held the view that food regulation and quality assurance issues was not the main issue when the RFID trial was implemented. This impression was supported by the following statement:

*“I guess it sort of, I’m not sure of how the question [question 11, see Appendix 1.1] really fits with the trial because it was a simulated shipping using water bottles in a truck, just to see whether the tags worked, rather than to ... We weren’t so much looking at temperatures. It was more looking at doing the temperatures line up between the two technologies and is the technology reliable, so and in this case it’s probably not such a ...it wasn’t for a quality assurance outcome in that anyway” (Case D: 114-119).*

Organisation A stated that food regulation and quality assurance issues were not considered to be drivers of the adoption of active RFID technology. When asked how the use of active RFID technology contributed to meeting the goals of quality assurances, the participant responded:

*“We had a fairly good database already. We had, from all previous work done with business for 15-18 years” (Case A: 320-321).*

## Food Regulation and Quality Assurance Issues

**Table 5-12. Summary the Relationship of Five Cases Between Food Regulation and Quality Assurance Issues and Three Matrices**

Case	Change Matrix			Effects Matrix: Direct, Meta and Side Effects			Explanatory Effects		
	Immediate Changes	Secondary Changes	Preferred Changes	Direct Effects	Meta Effects	Side Effects	Short-term Operational	Mid-terms Tactical	Long-term Strategic
A									
B	√	√		√	√			√	√
C	√	√		√					
D	√			√					
E	√	√	√	√		√			

√ = issue identified

### 5.2.5 Comparison between Five Cases: Limitations of Technology

The level of limitations of technology impact varied between the different cases, as shown in Table 5-13. Organisations A and E perceived there to have been an equal number of issues relating to the limitations of the use of active RFID technology for time-temperature monitoring. For example, this was identified for Organisations A and E in all aspects of the matrices with four exceptions. For Organisation A these exceptions were *Meta Effects* and *Side Effects* in *Effects Matrix: Direct, Meta and Side Effects*, *Short-term Operational* and *Mid-terms Tactical* in *Explanatory Effects Matrix*. For Organisation E *Preferred Changes* in *Change Matrix*, *Meta Effects* in *Effects Matrix: Direct, Meta and Side Effects*, *Mid-terms Tactical* and *Long-term Strategic* in *Explanatory Effects Matrix* were the exceptions.

This can indicate that Participant A had some concerns about the limitations of technology. As he stated:

*“I think we found a couple that were more than one degree out and we just threw those away. But that’s a bit of an issue” (Case A: 220-221).*

*“And one of the other things, and this drives me absolutely nuts, you have to put in your password every time you download a logger, which is nonsense” (Case A: 264-266).*

*“The other thing is you can have there is sort of central register of the loggers that you have currently set up and you sometimes pick up the logger and you go to read it and will say logger is already running but you can’t do anything with it. You can’t switch it off, you can’t, all you can do is you go through all your different consignments and try, and you keep trying and trying and I have loggers I can’t work out which consignment they are attached to and they just keep running, and I can’t switch off or do anything with them. So, they are some real issues around the that implementation side of it and there should be a generalised place where you can actually put a logger on, switch it off, even set up ten of them back to back and then attach them to the consignment” (Case A: 267-277).*

Participant A related the limitations of the technology to the cost of software license fees:

*"They quite literally back you into using the 'Organisation RFIDS' server, and I see that as a real weak point. And we are sort of happy to continue with 'Organisation RFIDS' but if another offer became available where we could if fact just do it all in-house as we do with the classic data logger, and still have access to this outside server where we could send stuff off shore" (Case A: 237-242).*

*"There is a bit of an issue there in the fact that I would like to be able to buy the data loggers, buy the readers, buy the front end run it in-house we never deal with 'Organisation RFIDS', I don't give the shit it doesn't matter, but that's currently not possible with these loggers" (Case A: 245-248).*

Participant E strongly suggested that the limitations of the technology had proved to be a barrier to the adoption of the technology. As stated:

*"We ran the trial with the 'Organisation RFIDS's system, and I was fairly pleased with the results. Except the fact that we could not use it in practice, because of the limitations.....We have done all sorts of things, so we needed something fairly sturdy, easy to handle, simple to retrieve, and simple to use..... I would have preferred something fully covered with plastic or, it is, but I was a little bit concerned about it" (Case E: 237-243).*

*"Yes, but just to stay practical we would like to have a system that would work for both types of products. Very simple to operate" (Case E: 410-411).*

The participant went on to say:

*"The main concern for us is that we need a logger that can stay switched on and do all these things for up to eight weeks, which would include time in the warehouse, overseas, the journey and unloading here in Australia" (Case E: 414-416).*

*"At the moment our company is considering any other options we looking basically, you know, and something similar to 'Organisation RFIDS's system" (Case E: 80-81).*

*"This is an issue that we have with things like metal detectors for ice cream. It is very difficult to chill them and calibrate them and they are not particularly sensitive. Because if you've got a, say, container product that is wrapped in sleeves with a metallic finish we have got problems" (Case E: 89-91).*

Other costs of the technology, such as the RFID tags, RFID readers and software license fees, were also perceived by the participant to have a negative influence on the adoption of active RFID technology. For example, the participant stated:

*"The costing was somehow complicated um, they were charging us for a hit on the database and downloads. So, if they had to buy a product, a data logger with a longer range or more hits, and their cost structure was more straightforward so we could actually work out our costings" (Case E: 67-70).*

*"I also told him that it is very complicated invoicing process. And he said that they would simplify that. So, because what they have offered us in the past, it is very kind of messy, they charge is to hit, and then they charge some standard usage fees per month. And it looked messy, and it was very difficult to determine how much we needed to spend" (Case E: S22-26).*

In Organisations B and D less concern was shown about limited technology than in Organisations A and E. It was noted that Organisation B was in the initial stage of implementing active RFID technology. Therefore, it was too early to determine any limitations of the technology. As the participant stated:

*"We've sort of benched this project a little bit and we just haven't had the time to really follow it through properly" (Case B: 253-254).*

The situation was similar in Organisation D, where again there had been only limited experience with the technology. As the participant commented:

*“We’ve had a bit of a play with them but we haven’t had any projects involved with them at this stage” (Case D: 21-22).*

For Organisation C the limitations of the technology was not an issue. Here, the participant suggested that such limitations did not have any impact on the organisation. The result suggests that there was a lack of interest in time-temperature monitoring equipment in this organisation because little related effort had been made by the participant. He expressed the view:

*“I can’t see any drawbacks of the technology because I’m not interested in it” (Case C: S38).*



## Limitations of Technology

**Table 5-13. Summary the Relationship of Five Cases Between Limitations of Technology and Three Matrices**

Case	Change Matrix			Effects Matrix: Direct, Meta and Side Effects			Explanatory Effects		
	Immediate Changes	Secondary Changes	Preferred Changes	Direct Effects	Meta Effects	Side Effects	Short-term Operational	Mid-terms Tactical	Long-term Strategic
A	√	√	√	√					√
B		√							
C									
D		√							
E	√	√		√		√	√		

√ = issue identified

### 5.2.6 Comparison between Five Cases: Relationship to Supply Chain Partners

During the interviews the relationship to supply chain partners variables and the use of active RFID technology for time-temperature monitoring were discussed. The actual occurrence of these variables varied across the five cases, as shown in Table 5-14. This table indicates that Organisation B perceived that the relationship to supply chain partners had been a very important driver in the adoption of active RFID technology. For example these were identified in all aspects of the matrices with only two exceptions. These exceptions were *Side Effects* in *Effects Matrix: Direct, Meta and Side Effects*, and *Short-term Operation* in *Explanatory Effects Matrix*. These results suggest that Organisation B was more supply partner orientated, and Organisation E was more concerned about their relationship with their supply chain partners.

Organisation B identified that having closer relationships with large supermarkets and overseas customers contributed to the perceived importance of active RFID technology. Organisation B also considered that having closer relationships with supply chain partners had been crucial in ensuring that the cold chain management met the requirements of large supermarkets, and sought to prevent the loss of overseas customers. These external factors directly effected the adoption of active RFID technology within Organisation B as the participant stated:

*“We have to test our product regularly particularly for our Japanese clients and that is not a requirement of AQIS or anyone it’s our relationship with them so we are happy to share this information” (Case B: 524-527).*

*“We’re now supplying a Woolworth’s warehouse direct on a daily basis. As we are now direct suppliers, so we have got to go through quality assurance, all of the quality assurance etc. So, now, our cold chain management is probably more important from their point of view” (Case B: S274-276).*

More specifically, several direct relationships were identified by Organisation E as being important to the level of perceived success associated with the management of

relationships with supply chain partners. In addition, the experiences reported at Organisation E illustrated how relationships to supply chain partners caused many issues for them. For example, the participant commented:

*“With the insurance companies, if we claim and damage, then we need to deal with the insurance company, we need to deal with their shipper, and it can approximately 10 months to get any resolution. In the meantime, we keep the stock in the warehouse, and we paid for it and nobody will reimburse us for that. So, sometimes we enter into negotiations, and we say okay, well, we are going to dump the product. Because we paid and that sort of amount of money per pallet, per week. And it keeps accumulating. So the cost, this cost, the cost of a quality, the cost of writing off the product, dumping the product, finance department in being involved in the logistics and quality assurance” (Case E: 58-64).*

In Organisation D, less concern was shown about relationships with supply chain partners than in Organisations B and E. Participant D had a strong knowledge and research base in the science of food safety, and was not directly involved with other supply chain partners (except ‘Organisation PDC’). As the participant stated:

*“My experience of red meat is just through ‘Organisation PDC’. Um, not that I am closely aligned with the red meat industry myself” (Case D: S83-84).*

Neither of the remaining two Organisations (A and C) identified any issues in relation to the relationships with their supply chain partners in adopting and using time-temperature monitoring technology. In addition, none of the cases mentioned the relationship to supply chain partners as agents that supported change.

## Relationship to Supply Chain Partners

**Table 5-14. Summary the Relationship of Five Cases Between Relationship to Supply Chain Partners and Three Matrices**

Case	Change Matrix			Effects Matrix: Direct, Meta and Side Effects			Explanatory Effects		
	Immediate Changes	Secondary Changes	Preferred Changes	Direct Effects	Meta Effects	Side Effects	Short-term Operational	Mid-terms Tactical	Long-term Strategic
A									
B	√	√	√	√	√			√	√
C									
D	√		√	√				√	√
E	√	√	√	√		√		√	

√ = issue identified

### 5.2.7 Comparison between Five Cases: Recovery of Information Using Time-temperature Monitoring Equipment

As shown in Table 5-15, Organisations A, B and C identified recovery of information as of importance in the adoption of active RFID technology for time-temperature monitoring. For Organisation A this was identified in all three change effects in *Change Matrix* and *Direct Effects* in *Effects Matrix: Direct, Meta and Side Effects*. As Participant A stated:

*“So, there are a lot of issues as soon as they go out of our control and into a cold chain a lot of issues about actual getting them back and getting them back in good time to be useful..... The receivers and transporters are very unwilling to do that because it seen as being intrusive, there is a mindset there that we have to get over it we have to make this work. Oh, sending them to Japan even people with readers it has still take us to 2 weeks to get them back. At which point you may as well send over a normal data logger that people recognise as a data logger, recognise it as an expensive piece of equipment and threat it as an expensive piece of equipment. So, to what extent, one of the issues with these credit card data loggers, is the people who receive them don't recognise the value of them ok. Because they see the physical object and they don't understand the value of the information in it so, they don't recognise the real value of it, so they don't treat it as an object with great value” (Case A: 110-126).*

Participants B and C also identified the recovery of information from RFID devices as being a problematic issue, and that ultimately the value of the information recovered was worth more than the RFID equipment.

## Recovery of Information Using Time-temperature Monitoring Equipment

**Table 5-15. Summary the Relationship of Five Cases Between Recovery of Information Using Time-temperature Monitoring Equipment and Three Matrices**

Case	Change Matrix			Effects Matrix: Direct, Meta and Side Effects			Explanatory Effects		
	Immediate Changes	Secondary Changes	Preferred Changes	Direct Effects	Meta Effects	Side Effects	Short-term Operational	Mid-terms Tactical	Long-term Strategic
A	√	√		√					
B		√							
C		√		√					
D									
E									

√ = issue identified

5.2.8 Summary of the Findings of the Cross-case Analysis

All of the key identified issues, ROI, change management, time-temperature monitoring, food regulation and quality assurance issues, limitations of technology, and relationship to supply chain partners, directly contributed to the decisions to adopt active RFID technology for Organisations B and E. Organisation A was more concerned with ROI, change management, limitations of technology and recovery of information using time-temperature monitoring. In Organisation C only moderate concerns were expressed in relation to ROI, change management, time-temperature monitoring and food regulation and quality assurance issues. This provides support for the view that the participant did not strongly support the adoption of the technology. ROI, change management, time-temperature monitoring, food regulation and quality assurance issues, limitations of technology, and relationship to supply chain partners were identified as having a direct influence on the adoption of the technology within Organisation D.

The aim of Table 5-16 is to provide a holistic summary of the findings between the seven variables and cross-case analysis. In this table the degree of importance with which each is regarded by individual cases is shown.

Table 5-16. Summary of the Relationship Between Seven Variables and Five Cases

Variables	Important	Less Important	Not Important
ROI	Case A, E	Case B	Case C, D
Change management	Case B, E	Case C	Case A, D
Time-temperature monitoring	Case B, E	Case A	Case C, D
Food regulation and quality assurance issues	Case B	Case D, E	Case A, C
Limitations of technology	Case A, E	Case B, D	Case C
Relationship to supply chain partners	Case B, E	Case D	Case A, C
Recovery of information using time-temperature monitoring equipment	Case A	Case B, C	Case D, E

### 5.2.9 Summary of the Findings of the Cross-case Analysis for Similarities

The aim of this section is to build on the results provided in the previous section. It will involve analysing the similarities between each of the five cases based on the seven issues:

- Return on investment;
- Change management;
- Time-temperature monitoring;
- Food regulation and quality assurance issues;
- Limitations of technology;
- Relationship to supply chain partners; and
- Recovery of information using time-temperature monitoring equipment.

The process of identifying these similarities involved the construction of tables where all the specific issues related to different perspectives of the matrices tables were directly linked back to the transcripts. From this, similarities based on specific issues were then used to construct seven further tables that will be presented and interpreted within this section. The more comprehensive tables that formed the basis for this expanded analysis can be found as Appendix 4.

#### 5.2.9.1 Comparison of Similarities Between the Cases: ROI

Despite ROI being a point of the questions addressed to each participant in the initial interviews, the only related common point dealt with the cost of the monitoring technology, and this commonality applied only to Organisations A and B. This may be due to the lack of knowledge and experience with the monitoring technology.

As Table 5-17 shows, the ROI issue and the cost of the technology was identified as being as an issue under *Immediate Changes* for both Organisations A and B. This was because Organisation A viewed senior management commitment as a foundation for addressing changes in implementing active RFID technology for time-temperature monitoring. The difficulty demonstrating ROI in order to gain



senior management commitment can be attributed to low levels of adoption. The commitment to providing financial resources for the technology contributed directly to the perceived effectiveness of the adoption of the technology. The main form of this commitment was either through the provision of resources or providing strong driving support for RFID pilot trials. The participant did not see the cost of the technology as a drawback to adoption of the technology. The low cost of active RFID technology meant that the organisation could monitor their cold chain and guarantee that correct handling procedures were being followed. In contrast, the cost of the technology was considered to be a driver to its implementation in Organisation B. However, although there had been little change in the cost of the technology at the time of the interviews and this was expected to change in the future. These changes are expected to be manifested when Organisation B adopted time-temperature monitoring equipment.

Organisations C and D indicated that the cost of the technology is not an issue for them as they were not interested in the technology. Given the nature of the business focus in Organisation E, cost was not an issue.

## Return on Investment (Similarities)

**Table 5-17. Similarities in ROI Between the Five Cases**

<i>Change Matrix</i>			<i>Effects Matrix: Direct, Meta and Side Effects</i>			<i>Explanatory Effects</i>		
<i>Immediate Changes</i>	<i>Secondary Changes</i>	<i>Preferred Changes</i>	<i>Direct Effects</i>	<i>Meta Effects</i>	<i>Side Effects</i>	<i>Short-term Operational</i>	<i>Mid-terms Tactical</i>	<i>Long-term Strategic</i>
<ul style="list-style-type: none"> <li>Cost of the technology (A, B)</li> </ul>								

### 5.2.9.2 Comparison of Similarities Between the Cases: Change Management

As shown in Table 5-18 with respect to Change Management, Organisations A, C and E had a similar goal of achievement of competitive advantages through the adoption of time-temperature monitoring at the *Immediate Changes*, *Secondary Change* and *Mid-term Tactical* levels. However, it was also found to be an issue in Organisation B, related to *Direct Effects*.

Participants A and E indicated that there had been a positive change in the flow of information that can be directly attributed to the implementation of active RFID for time-temperature monitoring. This improvement had generated a variety of benefits, such as the ability to:

- Better control what was happening during the distribution of finished products;
- Identify quality issues with products, these quality issues could then be linked to consumer complaints and the root cause of problems identified;
- Monitor the temperature and truck movements during delivery;
- Improve customer service;
- Reduce cost of quality assurance; and
- Reduce additional cost of writing off finished products.

For Organisation B the *Direct Effects* associated with Change Management can be explained as the organisation had only implemented active RFID technology as a basic informal trial. Therefore the consequences of this trial did not appear in *Immediate* and *Secondary Changes*. The low level of achievement for Organisation C is due to the nature of the products, size of the organisation and financial support. As a result Participant C did not consider that time-temperature monitoring equipment could bring longer term benefits to his organisation.

Trials with active RFID technology for time-temperature monitoring had occurred in Organisations B, D and E and had generated *Immediate Changes*, *Secondary Changes* and *Direct Effects*.

Participants A and B also revealed that they did not change any systems or processes as a result of trials with active RFID.

The quality and reliability of active RFID technology was found to be a common issue/concern in Organisations A, B, C and E, related to *Immediate Changes* and *Direct Effects*.

Experiences with trials with the technology in three cases (A, B and E) revealed some negative assessments, while they agreed that they were very pleased with the result of the trials. They also agreed that active RFID technology could not be used in practice because of its limitations. Participant D pointed out the technology was too old. Organisation C did not show any interest in the issue as he does not see the importance of the technology.

Interest in time-temperature monitoring technology had similarities in Organisations B, C and E related to *Secondary Changes* and *Direct Effects*. However, it was also found to be an issue in Organisations B and E that was related to *Preferred Changes* and *Mid-terms Tactical*.

For Organisation B active RFID was no longer optional as they needed to accommodate the requirements of large retailers and also comply with new food safety regulations. For Organisation E the key driver of the level of interest in the technology was quality assurance for the purpose of brand protection. The participant saw the cost of using time-temperature monitoring equipment justified on the basis of reduction in costs associated with inspection and testing of imported goods. A further outcome was the ability to pinpoint the cause of problems in order to provide evidential material for use in legal disputes over handling and storage. In contrast, the intention to develop time-temperature monitoring equipment was not considered at Organisation C. The participant did not associate any value with the technology or the benefit that it could provide. Other negative effects that have occurred from a lack of support at Organisation C have included low levels of financial support, size of the business and nature of products, little interest in attempting to improve and develop the technology and the decision not to invest in the technology for their cold chain management.

Organisations A and D did not identify any interest in the technology. Participant A frequently commented that there was a lack senior management commitment to the adoption of active RFID technology and that this negative attitude was permeating down to the level of interest in the technology. Participant D focused on Nano-Corn Node technology than active RFID technology. Also, the participant did not identify any results from the RFID trial as he had signed a confidentiality agreement with the 'Organisation RFIDS'.

## Change Management (Similarities)

**Table 5-18. Similarities in Change Management Between the Five Cases**

<i>Change Matrix</i>			<i>Effects Matrix: Direct, Meta and Side Effects</i>			<i>Explanatory Effects</i>		
<i>Immediate Changes</i>	<i>Secondary Changes</i>	<i>Preferred Changes</i>	<i>Direct Effects</i>	<i>Meta Effects</i>	<i>Side Effects</i>	<i>Short-term Operational</i>	<i>Mid-terms Tactical</i>	<i>Long-term Strategic</i>
<ul style="list-style-type: none"> <li>• Achievement of competitive advantage through time-temperature monitoring (A, C, E)</li> <li>• Trials with time-temperature monitoring (B, D, E)</li> <li>• Quality and reliability of RFID technology (A, C)</li> </ul>	<ul style="list-style-type: none"> <li>• Achievement of competitive advantage through time-temperature monitoring (A, C, E)</li> <li>• Trials with time-temperature monitoring (B, D, E)</li> </ul>		<ul style="list-style-type: none"> <li>• Achievement of competitive advantage through time-temperature monitoring (A, B, C, E)</li> <li>• Trials with time-temperature monitoring (B, D, E)</li> <li>• Quality and reliability of RFID technology (B, E)</li> </ul>				<ul style="list-style-type: none"> <li>• Achievement of competitive advantage through time-temperature monitoring (A, C, E)</li> </ul>	

<i>Change Matrix</i>			<i>Effects Matrix: Direct, Meta and Side Effects</i>			<i>Explanatory Effects</i>		
<i>Immediate Changes</i>	<i>Secondary Changes</i>	<i>Preferred Changes</i>	<i>Direct Effects</i>	<i>Meta Effects</i>	<i>Side Effects</i>	<i>Short-term Operational</i>	<i>Mid-terms Tactical</i>	<i>Long-term Strategic</i>
	<ul style="list-style-type: none"> <li>Interested in time-temperature monitoring technology (B, C, E)</li> </ul>	<ul style="list-style-type: none"> <li>Interested in time-temperature monitoring technology (B, E)</li> </ul>	<ul style="list-style-type: none"> <li>Interested in time-temperature monitoring technology (B, C, E)</li> </ul>				<ul style="list-style-type: none"> <li>Interested in time-temperature monitoring technology (B, E)</li> </ul>	

### **5.2.9.3 Comparison of Similarities Between the Cases: Time-temperature Monitoring**

As shown in Table 5-19 Organisations A, C, D and E had a similar use of time-temperature monitoring to monitor environmental factors related to *Immediate Changes* and *Direct Effects*.

Participants A, D and E considered the major benefits from the adoption of active RFID technology for time-temperature monitoring to be an improvement in the delivery of products in good conditions. They all agreed that fluctuations in temperature, heat and humidity levels during transportation impacted directly on food safety. In contrast, Participant C stated that the company had experienced almost no organisational impact. He reported that these minimal changes in time-temperature monitoring were causing it to be perceived negatively in relation to its effectiveness. Even though Organisation B was also concerned about quality assurance of their products, time-temperature monitoring was not an issue as the participant did not see an immediate need to adopt the technology.

The goal of achievement of competitive advantages through the adoption of time-temperature monitoring was common in Organisations B and E, based on *Preferred Changes* and *Direct Effects*.

The responses from Organisations B and E support the assertion that there is a relationship between positive changes in the adoption of active RFID technology for time-temperature monitoring and the level of perceived success associated with achievement of competitive advantage. This achievement took two principal forms, either making the cold chain management more effective by allowing products to be monitored all the way through to customers, or by ameliorating food safety and quality assurance issues. However, this result is not particularly surprising as improvements in cold chain management and quality assurance are arguably the most likely positive impacts to occur following the implementation of the technology. The fact that all the cases, except Organisation C, had experienced some positive changes in the use of the technology, may explain why none considered that their adoption cold chain management to be of no value.



## Time-temperature Monitoring (Similarities)

**Table 5-19. Similarities in Time-temperature Monitoring Between the Five Cases**

<i>Change Matrix</i>			<i>Effects Matrix: Direct, Meta and Side Effects</i>			<i>Explanatory Effects</i>		
<i>Immediate Changes</i>	<i>Secondary Changes</i>	<i>Preferred Changes</i>	<i>Direct Effects</i>	<i>Meta Effects</i>	<i>Side Effects</i>	<i>Short-term Operational</i>	<i>Mid-terms Tactical</i>	<i>Long-term Strategic</i>
<ul style="list-style-type: none"> <li>• Use of time-temperature monitoring to monitor environmental factors (A, C, D, E)</li> </ul>		<ul style="list-style-type: none"> <li>• Achievement of competitive advantage through time-temperature monitoring (B, E)</li> </ul>	<ul style="list-style-type: none"> <li>• Use of time-temperature monitoring to monitor environmental factors (A, C, D, E)</li> <li>• Achievement of competitive advantage through time-temperature monitoring (B, E)</li> </ul>					

#### **5.2.9.4 Comparison of Similarities Between the Cases: Food Regulation and Quality Assurance Issues**

As shown in Table 5-20, Organisations B, C, D and E had similar food regulation and quality assurance issues, based on *Immediate Changes* and *Direct Effects*. Food regulation and quality assurance were also found to be issues for Organisations B, C and E, related to *Secondary Changes*.

Participants B, D and E considered the change of food regulations and quality assurance issues to be positively affected the recognition within these organisations of the benefits that active RFID technology for time-temperature monitoring can provide. This was considered to be leading to the increase in the adoption of the technologies, and consequent perceived effectiveness and value. An additional benefit that was identified by them was the ability to pinpoint cause of problems in their cold chain distribution. Organisation E gave specific examples of how the technology could reduce problems associated with quality assurance.

There were no changes in quality assurance procedures associated with the adoption of the technology in Organisation A, as it already had a well compiled database of handling conditions over 15-18 years, and, as such, did not require significant changes. Participant A confirmed that the current handling conditions are adequate, and that production monitoring can be performed at low cost and with a high ease of use.

The importance of quality assurance in increasing quality of products was common across Organisations C and E in *Immediate Changes* and *Direct Effects*. Participant E indicated that changes in quality assurance practices had a direct positive impact on the quality of products. This was in contrast to Organisation C where the participant indicated that quality assurance of products was not an important issue as long as product survived the distribution process. Participant C thought that the nature of the product and the season of harvesting are the main factors in determining survival. The participant also indicated that there was a lack of interest in time-temperature monitoring equipment, partly because there had been no effort had been made to investigate it.

## Food Regulation and Quality Assurance Issues (Similarities)

**Table 5-20. Similarities in Food Regulation and Quality Assurance Issues Between the Five Cases**

<i>Change Matrix</i>			<i>Effects Matrix: Direct, Meta and Side Effects</i>			<i>Explanatory Effects</i>		
<i>Immediate Changes</i>	<i>Secondary Changes</i>	<i>Preferred Changes</i>	<i>Direct Effects</i>	<i>Meta Effects</i>	<i>Side Effects</i>	<i>Short-term Operational</i>	<i>Mid-terms Tactical</i>	<i>Long-term Strategic</i>
<ul style="list-style-type: none"> <li>• Food regulation and quality assurance issues (B, C, D, E)</li> <li>• Importance of quality assurance in increasing quality of products (C, E)</li> </ul>	<ul style="list-style-type: none"> <li>• Food regulation and quality assurance issues (B, C, E)</li> </ul>		<ul style="list-style-type: none"> <li>• Food regulation and quality assurance issues (B, C, D, E)</li> <li>• Importance of quality assurance in increasing quality of products (C, E)</li> </ul>					

#### **5.2.9.5 Comparison of Similarities Between Limitations of Technology**

As shown in Table 5-21, there was only one area of agreement between the cases, based on the limitations of technology issue. This was identified as being for *Secondary Effects* in Organisations A, B, D and E.

From their previous experience with active RFID for time-temperature monitoring, Participants A, B, D and E identified that the current active RFID technology was limited due to memory, RF range limitations, on-going software license fees, reliability and the accuracy of RFID tags. Participant A had broad experience in the more technical aspects of the technology and was able to provide valuable insights into the limitations of the technology. However, Participants B and D had previously implemented more basic active RFID technology, so that their knowledge of the limitations of the technology may not have been as comprehensive as for Participant A. Organisation E, prior to the adoption of active RFID technology examined in this research, had limited experience with the technology, and so the impact of the limitations of the technology was not as significant as for the other organisations that participated in this research.

## Limitations of Technology (Similarities)

**Table 5-21. Similarities in Limitations of Technology Between the Five Cases**

<i>Change Matrix</i>			<i>Effects Matrix: Direct, Meta and Side Effects</i>			<i>Explanatory Effects</i>		
<i>Immediate Changes</i>	<i>Secondary Changes</i>	<i>Preferred Changes</i>	<i>Direct Effects</i>	<i>Meta Effects</i>	<i>Side Effects</i>	<i>Short-term Operational</i>	<i>Mid-terms Tactical</i>	<i>Long-term Strategic</i>
	<ul style="list-style-type: none"> <li>Limited of time-temperature monitoring technology (A, B, D, E)</li> </ul>							

#### **5.2.9.6 Comparison of Similarities Between the Cases: Relationship to Supply Chain Partners**

With regard to relationship to supply chain partners, there was a similarity in *Preferred Changes*, *Direct Effects*, *Mid-terms Tactical* and *Long-term Strategic* issues for Organisations B and D. The similarity also occurred in *Immediate Changes* and *Secondary Changes*, *Immediate Changes* across Organisations B, D and E, while commonality in *Secondary Changes* was found in Organisations B and E.

Organisation B, in order to maintain market share and market leadership, required changes in the way they interact with large retailers, that required considerably higher levels of quality assurance during the transportation of products. For this organisation a key driver in this undertaking was a food safety and quality assurance orientation and also the necessity to be competitive with rivals that were using more advanced cold chain systems with greater tracking and traceability. More specifically, direct relationships with large retailers were identified by the participant as being important to the level of perceived effectiveness associated with the adoption of active RFID technology for time-temperature monitoring. Throughout the interview process, Participant E referred repeatedly to relationships with third parties and suppliers. He identified that the variability of handling conditions by third parties and suppliers was a major source of risk exposure for the organisation. In contrast, due to the nature of Organisation D, their relationship with suppliers was more focused on the trials with 'Organisation PDC' and 'Organisation RFIDS'.

## Relationship to Supply Chain Partners (Similarities)

**Table 5-22. Similarities in Relationship to Supply Chain Partners Between the Five Cases**

<i>Change Matrix</i>			<i>Effects Matrix: Direct, Meta and Side Effects</i>			<i>Explanatory Effects</i>		
<i>Immediate Changes</i>	<i>Secondary Changes</i>	<i>Preferred Changes</i>	<i>Direct Effects</i>	<i>Meta Effects</i>	<i>Side Effects</i>	<i>Short-term Operational</i>	<i>Mid-terms Tactical</i>	<i>Long-term Strategic</i>
<ul style="list-style-type: none"> <li>Relationship with supply chain participants (B, D, E)</li> </ul>	<ul style="list-style-type: none"> <li>Relationship with supply chain participants (B, E)</li> </ul>	<ul style="list-style-type: none"> <li>Relationship with supply chain participants (B, D)</li> </ul>	<ul style="list-style-type: none"> <li>Relationship with supply chain participants (B, D)</li> </ul>				<ul style="list-style-type: none"> <li>Relationship with supply chain participants (B, D)</li> </ul>	<ul style="list-style-type: none"> <li>Relationship with supply chain participants (B, D)</li> </ul>

#### **5.2.9.7 Comparison of Similarities Between Five Cases: Recovery of Information Using Time-temperature Monitoring Equipment**

As shown in Table 5-23 there was only one area of similarity within the recovery of information using time-temperature monitoring equipment. This issue was the problem of getting information and data loggers back and was identified as being as *Secondary Effect* and *Direct Effects* for both Organisations A and C.

Participant A viewed the recovery of expensive active RFID equipment for time-temperature monitoring as an issue. The main issue with recovery of RFID tags was the value of the data collected by the tags. He also identified that only half of the tags were recovered because supply chain participants did not recognise the value of the technology, and therefore tended to discard them. Another issue was that transport carriers are not happy with data logging as they see it as intrusive monitoring of their business operations. Participant A saw a need to recover data loggers in a short time frame for the data gathered to be useful. Therefore, an alternative was to have readers at both ends of the cold chain and have the data loggers read at the far end. This is a potential strength of active RFID technology, by installing RFID readers at distribution gateways, and transmitting the data back via the Internet. In Organisation C and E, the participants also viewed the recovery of information using time-temperature monitoring equipment as a fundamental issue for using the technology. However, the participants did not give any further details on this issue. In contrast, the participant in Organisation B did not consider the recovery of data from active RFID technology to be an issue.



## Recovery of Information Using Time-temperature Monitoring Equipment (Similarities)

**Table 5-23. Similarities in Recovery of Information Using Time-temperature Monitoring Equipment Between the Five Cases**

<i>Change Matrix</i>			<i>Effects Matrix: Direct, Meta and Side Effects</i>			<i>Explanatory Effects</i>		
<i>Immediate Changes</i>	<i>Secondary Changes</i>	<i>Preferred Changes</i>	<i>Direct Effects</i>	<i>Meta Effects</i>	<i>Side Effects</i>	<i>Short-term Operational</i>	<i>Mid-terms Tactical</i>	<i>Long-term Strategic</i>
	<ul style="list-style-type: none"> <li>Problem with getting information and data loggers back (A, C)</li> </ul>		<ul style="list-style-type: none"> <li>Problem with getting information and data loggers back (A, C)</li> </ul>					

### 5.2.10 Summary Holistic Nature of the Findings

Figure 5-12 provides a summary of the holistic nature of the findings chapter presented in this chapter.

The within-case analysis began with coding the interview transcripts to ensure standardised use of terms across all interviews. The three matrices (*Change Matrix*, *Effects Matrix: Direct, Meta, and Side Effects* and *Explanatory Effects Matrix*) and causal diagrams were employed as within-case displays to assist in visualisation and interpretation. Then the summary overview for each case study based on the findings from three matrices and causal diagram of findings were developed. During the cross-case analysis process, the seven variables were identified as being common across the five case studies. Then the comparison examines the similarities in these key variables across the five case studies was created. These comparisons resulted in the extraction of relationships that were found to be replicated across multiple cases, and abstracted from individual cases. The summary of the findings of the cross-case analysis for similarities is a final stage of the present exploratory investigation. These propositions were integrated into a comprehensive holistic conceptual model, which represented the best practice strategic decision-making model for the adoption of time-temperature monitoring for transport of perishable foods.

## Within-Case Analysis

## Cross-Case Analysis

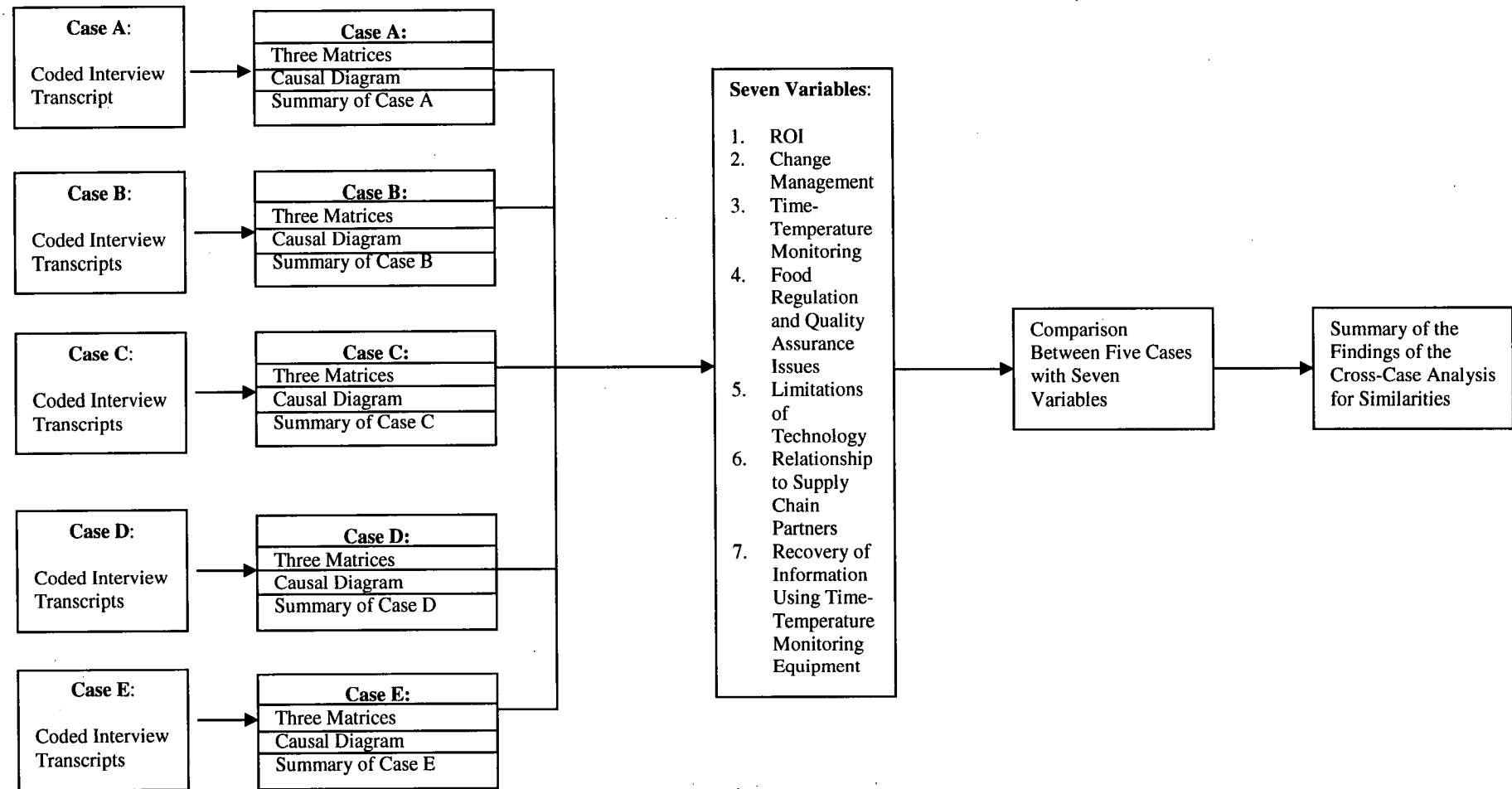


Figure 5-12. Summary Holistic Nature of the Findings

### **5.3 Summary Reflection**

This chapter has interpreted and discussed the findings of this research based on the within-case and cross-case displays from the five case studies. Each of the overall research objectives have been addressed in turn and several key variables and relationships identified that appear to influence the adoption of time-temperature monitoring equipment.

The chapter began by reporting the findings from within-case analyses. This was based on two processes of analysis: firstly, cause and effect matrices and secondly, causal diagrams. Following these the summary of the cases was provided. The cross-case display analysis was based on seven variables that were identified from the cause-effect matrices analysis. This cross-case analysis involved looking for similarities, based on the actual data from the case interviews. Finally, a summary of a holistic findings presented in this chapter was provided.

In the next chapter the conclusions of the study and future areas of research will be presented. In addition any limitations that have arisen based on the experience gained from the process of conducting this research will be acknowledged.

## **CHAPTER SIX: CONCLUSIONS & FUTURE WORK**

### **6.0 Introduction**

This thesis concludes with a discussion of the major outcomes of this research, together with the limitations of the research and finally, directions for future research are proposed.

### **6.1 The Objectives of the Research**

The objectives of this research were:

- To examine the impact of time-temperature monitoring equipment on the quality assurance of the transportation of perishable foods in selected case studies;
- To identify the issues of transporting perishable foods in selected supply chains; and
- To develop a model of the benefits of the use of time-temperature monitoring for the quality assurance of the transport of perishable foods in the selected case studies.

It is proposed that this research has achieved its research objectives. It has provided an in-depth examination on the use of time-temperature monitoring equipment on the quality assurance of the transportation of perishable foods based on the views of Senior Managers and business owners in the industry. It has also identified a number of issues related to the transportation of perishable foods and developed a model of the benefits that can be gained from the adoption of the technology.

### **6.2 Major Outcomes of this Research**

This multiple case research has provided evidence that a number of factors contribute to the perceived effectiveness associated with an adoption of time-temperature monitoring equipment for the quality assurance of perishable food during transportation. These are:

- Change management;
- Time-temperature monitoring equipment;
- Relationships with supply chain partners;
- Government regulations and quality assurance issues;
- ROI;
- Cost of recovery of time-temperature monitoring components; and
- Limitations of the technology.

Positive changes in the attitude of senior management taking part in this research towards the adoption of time-temperature monitoring equipment exist. This is evidenced by the first four factors (change management, time-temperature monitoring equipment, relationships with supply chain partners and government regulations and quality assurance issues).

The senior managers acknowledged that change management could support an improved ability to control their supply chain operations. This implies increased effectiveness and efficiency in the tracking and tracing of their products throughout the entire cold supply chain. This was seen as a means of addressing problems when, at certain points in the chain, product abuse occurs. While currently it can be highly problematic in identifying the source of contamination or degradation for insurance purposes, change management was seen as the means to promptly address such situations. A further positive outcome from supply change management was the potential achievement of a competitive advantage through the application of time-temperature monitoring equipment.

Time-temperature monitoring equipment has the potential to provide added benefits to supply chain participants. These depend on the nature of the products, duration of transportation, temperature and humidity during transport of perishable foods and reliability of active RFID technology. However, there exists a range of issues that may reduce these potential benefits that may not necessarily lead to relative advantages in real terms. To gain the most benefits from time-temperature monitoring equipment it is essential that the perishable food industry gains a

thorough understanding and knowledge of the equipment as it is relatively new in Australia.

Supply chain partner relationship was seen as an important factor influencing the adoption of time-temperature monitoring equipment. In the future supply chain management was seen as being a driver to the adoption of the technology. While it is not currently a universal practice in the perishable food industry, some major supermarket chains such as Woolworths and Coles are demanding it of their logistics service providers.

The participants in this research demonstrated an acceptance of food regulations and quality assurance standards. These were not seen as an imposition but rather as a means to develop widespread quality practices among Australian perishable food industry members. Supply chain management, service and reliability of logistics service providers and nature of products are all external factors over which the organisation has little control. Collectively these factors can significantly influence the potential for perishable food industries to derive benefit from time-temperature monitoring equipment. While RFID technology has the capability to make a considerable contribution to quality assurance standards the absence of radio spectrum management on a global basis at present is a barrier to its widespread adoption.

From the findings and the views of the research participants, the three negative factors from this research in relation to the adoption of time-temperature monitoring equipment are ROI, the cost of recovery of time-temperature monitoring components and the limitations of the technology. These factors can be seen as barriers to the adoption of active RFID technology, in keeping with Rogers' (1995) theory of diffusion of Innovation.

The difficulty in demonstrating any tangible ROI and unavailability of a concrete pay back period when the cost of the investment would be recouped has influenced the attitude of a majority of senior management towards the adoption of the technology. The exception came from the Manager from Organisation E who, because of his business focus in quality assurance, showed stronger commitment and willingness to adopt such technology for the environmental monitoring of

perishable food during transportation. However, more generally ROI was not seen as the most important factor when weighing up other justifications for the adoption of RFID. The problem of establishing a realistic pay back period cannot be addressed at this time because of the relatively low uptake of active RFID. As a result owners/managers in the perishable food industry, even though they acknowledge that it can reduce costs in some areas, are reluctant to implement time-temperature monitoring equipment in their food distribution chain.

The cost of recovery of time-temperature monitoring components along with the potential to lose information contained on the RFID tags was seen as high risk. So in the view of the participants, this factor was not conducive to support the implementation of time-temperature monitoring equipment. No easy solution to overcoming this problem was seen as it is outside the control of the organisation that might have adopted the technology. The longer the distribution network, the greater the chances of losing tags and the information stored on them. Those working in the distribution chain need to be educated in the purpose of the application of the technology. However, until RFID is accepted as a common practice in the perishable food industry, it is unlikely that this problem can be addressed.

The final negative factor as seen by the participants in this research was the limitations of the current state of development of RFID technology. At this time the reliability and accuracy of the technology was questioned. In particular this relates to the numbering system and the potential for duplication. A common complaint was that access to the service provider's web site was not always convenient. The issue of on-going license fees was also seen as not conducive to the implementation of time-temperature monitoring equipment.

In general it can be said that the relative newness of active RFID technology is central to the issues related to its uptake. It is a position that until more organisations are willing to adopt the technology many of these issues cannot be addressed.



## **6.3 Contributions to the IS Discipline**

This thesis makes a contribution to the field of Information Systems at three levels, theoretical, substantive and methodological.

### **6.3.1 Theoretical Contribution**

From a theoretical perspective, this research contributes knowledge in a number of areas:

- This research has contributed to the foundation of a normatively theoretical model of the adoption of technology within this particular topic. While these models are normative, they do not claim to be generalised beyond the scope of the case studies considered. Most of the published material in this area has focussed on retail and logistics and supply chain management perspectives. There is very little research in the time-temperature monitoring equipment for quality assurance of perishable food during transportation;
- The development of cause and effect model relationships of time-temperature monitoring equipment for quality assurance of perishable food during transportation utilisation among perishable food industries for selected case studies;
- It has developed initial causal diagrams of the benefits of the adoption of time-temperature monitoring equipment for quality assurance of perishable food during transportation for selected case studies; and
- This exploratory research has established a framework for further research. Some proposals for the direction of research will be put forward later in this chapter.

### **6.3.2 Substantive Contribution**

From a substantive perspective, this thesis has:

- Provided a foundation for the understanding of factors involved in the adoption of time-temperature monitoring equipment for quality assurance of perishable food during transportation within selected case studies;

- Provided a source of reference to encourage food processing and distribution companies to implement time-temperature monitoring all along the cold chains in order to improve quality assurance of perishable products; and
- Provided information for perishable food industries that can assist them in identifying issues associated with the custody of products, environmental parameters and maintenance of goods during cold chain distribution.

### **6.3.3 Methodological Contribution**

At a methodological level the thesis combines three analytical techniques, using the qualitative analysis methods for identification of cause-effect relationships from Miles and Huberman (1984, 1994). These techniques seek to explain causal relationships in each of the case studies. In addition, the use of critical analysis and the identification of similarities across case studies have contributed to the outcomes of the research. These three qualitative data analysis techniques have employed a deductive approach to theory generation where theories, concepts and models were grounded in the available data.

Another key contribution of this study has been to demonstrate how qualitative research methodologies can be employed within a post-positivist epistemology for:

- Explanation-building;
- Development of effect-outcome explanatory matrices; and
- Analytic model construction.

### **6.4 Limitations of the Study**

This thesis examined a small number of case studies from perishable food sector in three regional areas in Australia. The research was of an exploratory nature, and the scope of the research aimed to gain an insight into the adoption of time-temperature monitoring equipment from selected case studies.

Inevitably, there are a number of limitations of the research that was exploratory in nature and bounded by the constraints of a post-graduate candidature. These limitations mainly relate to the scope of the research design, namely: sampling size and data collection as well as the extent of data analysis.

The use of time-temperature monitoring equipment for quality assurance of perishable food during transportation in Australia is relatively new. Therefore, the availability of the case studies of supply chain participants who had knowledge of time-temperature monitoring equipment for quality assurance purposes was very limited. The difficulty in gaining participants for this study is acknowledged as a limitation of the research.

The study and its outcomes are limited to the specific case studies and the data gathered from the participating companies. No claims are made of the generalisation of the findings of this research beyond these case studies.

## **6.5 Future Research**

This thesis has provided an exploratory study on the utilisation of time-temperature monitoring equipment for the quality assurance of perishable food during transportation in order to be able to improve/maintain quality assurance of perishable food chains. Each case study has produced different responses to questions on the above issues, as one would expect, because each type of food product has its own particular handling and cold chain management requirements.

The present research has been established as exploratory due to the lack of evidence of any empirical research in the area. As such it is envisaged that future work could expand upon this investigation to further investigate various aspects of this research. The data obtained as a consequence of this present study presents ample opportunity for further work. Suggested future directions are:

- The development of a richer understanding of the nature of time-temperature monitoring equipment for quality assurance of perishable food during transportation within a broader range of industry sectors;
- A further exploration of factors that affect the development, implementation and support of time-temperature monitoring equipment for quality assurance of perishable food during transportation by perishable food industries. In this regard it would also be useful to investigate if, and how, organisations change their utilisation of time-temperature monitoring

equipment for quality assurance of perishable food during transportation over time;

- The views of businesses that are not utilising time-temperature monitoring equipment and associated identification of inhibitors would provide a more complete view of time-temperature monitoring utilisation by food industries;
- There is a need for further research to explore and evaluate the basic models developed in this research, in order to improve their validity when applied to actual business models;
- Further research and analysis could be conducted into the relationships between the adoption of the time-temperature monitoring equipment and the achievement of quality assurance outcomes; and
- In this research economies of scale and the benefits of time-temperature monitoring equipment in the transportation of perishable food have been recognised as important factors. These economic perspectives could be investigated in greater detail, especially to develop a better understanding of the case for return on investment from the adoption of this technology.

## **6.6 Concluding Reflections**

In conclusion this thesis aimed to broaden the knowledge, understanding and theory in regard to the adoption of technology for time-temperature monitoring among perishable food chains. The thesis has provided a substantive, methodological and theoretical contributions to the IS, food safety science and economic disciplines. The researcher hopes that aspects of this thesis will be of assistance to those perishable food industry practitioners and researchers who are actively considering or utilising the technology. The knowledge that this research has the potential to generate and encourage further interest in time-temperature monitoring equipment for quality assurance of perishable food during transportation by other academics and practitioners is a source of satisfaction to the author.